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CONFERENCE REPORT

ON

COTTON INSECT RESEARCH AND CONTROL

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This is the report of the thirteenth annual conference of State and Federal workers concerned with cotton insect research and control. Research and extension entomologists and associated technical workers from 12 cotton-growing States, the United States Department of Agriculture, and the National Cotton Council of America met to review the research and experiences of the previous years and to formulate a guiding statement for control recommendations in 1960.

In addition to recommendations for the use of insecticides against cotton insects, the Conference Report presents information of value (1) to industry in planning production programs and (2) to State and Federal workers who cooperate with cotton growers in testing materials still in the experimental stage. It contains information concerning cultural and biological control, surveys, and research needs and presents a general program by which extension entomologists may bring to the attention of growers and all other interested groups the control recommendations for each State.

This Conference Report is available, as long as the supply lasts, to entomologists and other research and extension workers and agencies interested in cotton production. Copies may be obtained from the Cotton Insects Research Branch of the Entomology Research Division, Beltsville, Md. The report may be duplicated in whole or in part, but not used for advertising purposes. However, no less than a complete section relating to one material or insect together with any supplemental statements should be copied.

RESEARCH--THE BASIS OF PROGRESS

Cotton insect research contributes to more efficient cotton production and offers hope of further reducing production costs and increasing profits. A continuing strong research program is essential if a favorable position is maintained in the battle with cotton pests. The ability of pests to develop resistance to highly effective insecticides emphasizes the need for a strong program of basic and applied research. New concepts and methods of control can come only through research.

During the past 15 years the use of insecticides has become an accepted practice on most cotton farms. Farmers generally recognize insect control as being as important in efficient cotton production as the use of fertilizers, proper cultivation, or any other production practice. Indeed, they know that in many instances unless the insects are controlled benefits from other approved practices may be lost.

Diapause is, to a large extent, the key to hibernation. The discovery of sexual diapause in the boll weevil has done much to explain the phenomenon of hibernation of this insect and has opened up new avenues which may lead to more effective and more efficient control. Factors which control diapause in the boll weevil and the pink bollworm are being studied and much new information is being obtained on this vital link in their life histories. Basic studies of nutrition and mass rearing have led to the establishment of a year-round laboratory supply of boll weevils and pink bollworms.

Basic or fundamental research is essential to the development of new concepts of cotton insect control. It is essential before major breakthroughs can be achieved in developing insect resistant cotton varieties, long-lasting systemic insecticides, the discovery of effective attractants, the solving of the insecticide resistance problem, and the maximum use of biological control.

Beyond this point lies the unknown. Long-term basic research on insect biology, physiology, biochemistry, behavior, ecology, etc., on the chemistry of insecticides, and on the physiology of the cotton plant will in time yield many valuable leads which should result in the development of new concepts of control and possible eradication.

Future research output is dependent on availability of personnel, facilities, and funds. It is particularly essential that present and future projects be more adequately supported. This involves the creation and maintenance of a "climate" favorable for productive research, with facilities, salaries, and other support adequate for attracting and keeping scientists of the caliber, training, and experience needed. Attention must be given to the need for cotton insect research facilities in regions not adequately served at present, such as the extensive and relatively new cotton-growing areas of the irrigated West. Those interested in the welfare of the cotton industry should encourage promising high school and college students to enter the field of professional entomology as teachers, research scientists, extension and survey entomologists, and field scouts.

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PURPOSES AND POLICIES

The chief purpose of the Cotton Insect Conference is to enable State and Federal entomologists to exchange information that may be useful in further research, survey, and extension work.

Although successful procedures, equipment, and materials have been developed for control of insects and spider mites on cotton, research is continually improving upon existing practices, and attempting to anticipate and meet new problems. It is desirable that results of research be made available to other cotton entomologists before they are made a basis for recommendations.

While agreement on over-all recommendations may be expected, complete standardization throughout the Cotton Belt is not possible. Details of recommendations must vary with the region or locality. Cotton growers should follow the advice of qualified entomologists in their respective States who are familiar with their local problems.

An adequate cotton insect control program involves consideration of several approaches including cultural, biological, and chemical methods. Chemical control should be resorted to only after full advantage has been taken of cultural and biological methods.

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to the hazards to the public.

The insecticide industry has a great responsibility to the cotton grower in making available adequate supplies of recommended materials which are properly formulated. Sales programs should be based on State or area recommendations.

Unfortunately, various so-called "remedies" for controlling insects have been put on the market through the years. Although some had slight value, most of them were less effective and more expensive than widely tested standard methods. Therefore, cotton growers are urged to follow approved recommendations.

INSECTICIDES AND MITICIDES

Insecticides and miticides useful for the control of cotton pests, and others still under investigation, are listed on page 17. They are grouped according to general type and the stage of their development for practical use. In local areas certain insects have become resistant to one or more of the insecticides recommended for general use. See statement on Resistance to Insecticides.

Hazards and Precautions in the Use of Insecticides

Development of new synthetic organic insecticides provides more effective means of controlling insects, but problems involving hazards to man, domestic animals, crops, fish, and beneficial wild life have been intensified by the use of these new chemicals, although some of them are actually not as toxic to man as are some of the old insecticides. Most insecticides may be harmful to man and animals if used in excessive amounts or if handled carelessly; therefore, they should be used with appropriate precautions and in the amounts and manner recommended. These precautions and recommended amounts are given on labels of all materials legally offered for sale. Most difficulties have resulted from failures to read and observe precautions stated on the labels. These materials should not be used unless the user is prepared to follow precautions on the labels.

Insecticide injury to man may occur through skin absorption or by oral or respiratory intake. Some solvents used in preparing solutions or emulsions are inflammable, and most of them are poisonous to some degree. In considering the hazards to man, it is necessary to distinguish between immediate hazards (acute toxicity) and accumulative hazards (chronic toxicity).

Research and experience have shown that most of the chlorinated hydrocarbons are reasonably safe at strengths normally applied to cotton. In concentrated form, however, they may cause acute poisoning. In addition, continued exposure to the lower concentrations may result in accumulation in the body with possible eventual tissue or organic injury.

Many of the insecticides used on cotton are extremely poisonous and must be handled with care at all times and in all forms. The physiological activity of organophosphorus compounds in both insects and warm-blooded animals is primarily inhibition of the cholinesterase enzyme. Repeated exposure to them may reduce the cholinesterase level gradually to the point where symptoms of poisoning may occur. These include headache, pinpoint pupils, blurred vision, weakness, nausea, abdominal cramps, diarrhea, and tightness in the chest.

The toxicity of compounds suggested for additional experimentation is in most cases not well known. Extreme precautions should be observed in their use until more information is available concerning their toxicity.

Preventing skin absorption.--Many of the new insecticides are almost as poisonous when in contact with the skin or eyes as when taken orally. Such contamination occurs through spillage and also through the

deposition of fine mist or dust during application of insecticides. Direct measurements of the exposure of agricultural workers during ordinary spraying procedures have shown the amount of poison deposited on the exposed parts of the skin was very much greater than the amount of poison which they inhaled. With the exception of aerosols, agricultural sprays and dusts have relatively large particles. When such particles are inhaled, they do not reach the lungs but are eventually brought into the throat and swallowed. Thus skin absorption is the greatest danger which agricultural workers face in using many of the new pesticides, and yet it is the route of absorption which they are most likely to ignore.

Liquid concentrates are particularly hazardous. Load and mix in the open. If the concentrate is spilled on the skin or clothing, wash the skin immediately and change to clean clothing. Contaminated shoes are a serious hazard. Bathe at the end of the work period. Launder work clothes daily and change shoes when necessary. Wear natural or other insecticide resistant rubber gloves while handling highly toxic compounds. Have at hand a change of clothing and soap and water in the field.

Preventing oral intake.--Keep food away from direct contact with all chemicals and also keep away from the possible fumigant action of volatile chemicals. Wash exposed portions of the body thoroughly before eating or drinking. Do not smoke or otherwise contaminate the mouth area before washing the face and hands.

Preventing respiratory intake.--Wear an approved respiratory device when using highly toxic phosphorus compounds or heavy concentrations of other insecticides. Decontaminate the respirator between operations by washing and replacing felts and/or cartridges at recommended intervals of use. An ARS release entitled "Respiratory Devices for Protection Against Inhalation Hazards of Dust, Mist, and Low Vapor Concentrations of Certain Insecticides" dated July 22, 1957, gives the latest information on respirators and gas-mask canisters that will afford protection against various insecticides.

Additional precautions.--Regular users of phosphorus compounds should have their blood cholinesterase level checked before the start of a season's work and periodically thereafter. It is advisable to have on hand a small supply of 1/100-grain atropine tablets for emergency use as recommended by medical authorities in case of poisoning. Field workers should be kept out of treated fields for whatever time seems advisable.

Excess dust or spray materials should be buried. Empty paper bags and cartons should be burned immediately in the open. Empty metal containers should be smashed beyond possibility of reuse and buried. Metal containers of emulsifiable concentrates carried to the field should be placed in the shade. Agitation of closed containers that have been left in the sun can result in pressure buildup in the container with a resultant exploding of the contents when the top is removed. Unused insecticides should be kept in the original container and stored in places inaccessible to children, irresponsible persons, or animals.

Advantage should be taken of wind direction and location of fields to avoid direct application of highly toxic insecticides to dwellings, stock barns, and highways.

Airplane pilots applying insecticides should not assist in mixing or loading the insecticides. Persons making ground application of cholinesterase inhibiting insecticides or loading aircraft with these materials should always be accompanied by at least one other person in the field.

Some sources of information on pesticide poisoning.--The Public Health Service of the U. S. Department of Health, Education and Welfare has issued a 25-page publication entitled "Directory of Poison Control Centers." The directory is currently out of print. A revision will be available in March 1960. It lists those facilities in each State which provide to the medical profession on a 24-hour daily basis information concerning the prevention and treatment of accidents involving ingestion of poisonous and potentially poisonous substances. Notations are made on those units which supply informational services only. This directory is available upon request to the Public Health Service, Accident Prevention Program, National Clearinghouse for Poison Control Centers, Washington 25, D. C. They also issue a 78-page publication entitled "Clinical Memoranda on Economic Poisons" which gives information concerning the health hazards, symptoms, pathology, diagnosis, treatment, and prevention of poisoning by economic poisons, including insecticides. This publication is available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at 30 cents per copy.

Residues on plants.--Spraying or dusting should be done under conditions and in a manner to avoid excessive drift to adjacent fields where animals are pastured or where food crops are being grown. Care in preventing drift is also essential because certain varieties of plants and kinds of crops may be injured by some insecticides.

In the development of new insecticides the possibility of deleterious residues remaining in cottonseed and seed products must be thoroughly investigated.

Cotton that has received late-season applications of calcium arsenate, Sevin, or any of the chlorinated hydrocarbon insecticides should not be grazed by dairy animals or by meat animals being finished for slaughter. Residues of calcium arsenate on cotton or in fields to which it has drifted are particularly hazardous to grazing animals.

Residues in soils.--Excessive insecticide residues in the soil may affect germination, rate of growth, and flavor of crops. Concentration of the residue is influenced by the insecticide or formulation used, the amount applied, the type of soil, and climatic conditions. Apparently there is no immediate hazard to the growth of any subsequent crops when amounts and concentrations recommended for the control of cotton insects are followed except in certain areas in the Carolinas where calcium arsenate is used on light sandy soils. Off-flavor in some root crops may result when grown in rotation with cotton that has received applications of BHC.

Protection of predators and parasites.--Predators and parasites play an important role in the control of cotton insects. Insecticides destroy beneficial as well as harmful insects; therefore, the control program should be integrated to take maximum advantage of chemical, natural, and cultural controls. The use of insecticides that are selective for the pest species concerned and of minimum detriment to the beneficial forms is desirable. Periodic inspections to determine populations of beneficial and injurious insects help eliminate unnecessary treatments. When high levels of predators and parasites are present, deferring of insecticide treatments should be considered.

Protection of honey bees.--Insecticides applied to cotton may cause heavy losses of honey bees. Not only does cotton produce excellent honey, but many cotton growers are also growing legumes or other crops that require insect pollination. For the benefit of beekeepers, cotton growers, and agriculture in general, every effort should be made to protect pollinating insects.

The effect on honey bees should be considered whenever chemicals are applied. Any evaluation of the hazard of a particular insecticide should take into account its toxicity to the bees, the amount applied per acre, and the exposure. Calcium arsenate, which kills colonies outright, is the most dangerous insecticide in wide use on cotton. Organic insecticides usually kill only the field bees; they do not usually destroy the colony. However, some of these materials kill more bees than others. Aldrin, BHC, dieldrin, Guthion, heptachlor, lindane, malathion, methyl parathion, parathion, and Sevin are highly toxic to honey bees; therefore, bees should be moved from the vicinity before these materials are used. In general dusts are more hazardous to bees than sprays. Aramite, DDT, demeton, dipterex, Kelthane, sulfur, Tedion, and toxaphene are of little hazard to bees.

To hold honey bee losses to a minimum, take the following precautions:

1. When practical, apply insecticides during hours when bees are not visiting the cotton plants.

2. When practical, use the insecticides least toxic to bees.

3. Avoid drift into bee yards and adjacent crops in bloom.

4. Beekeepers should keep informed of cotton-insect infestations and recommendations for their control. This knowledge will enable them to locate bee yards in the safest available places and to know where and when insecticide applications are likely to be made. They should also contact the cotton growers before the insect-control season begins, giving the location of their apiaries and requesting the growers' cooperation.

5. Cotton growers should notify beekeepers at least 48 hours before dusting or spraying, so that all possible protective measures can be taken.

6. County agents and other agricultural leaders should be given the exact location of apiaries. They should distribute such notification to beekeepers and recommend to cotton growers the materials least toxic to bees.

Honey bee losses can be reduced by complete understanding and cooperation between beekeepers and cotton farmers.

Protection of fish and wildlife.--Insecticides can be used for cotton insect control without appreciable injury to fish and other wildlife if recommended precautions are taken. It is especially important, however, to use minimum amounts where drift to ponds and streams is unavoidable. Runoff from treated fields should be diverted from fish ponds when possible. Where drift may create a problem, sprays are preferred to dusts and ground applications to aerial applications. Every precaution should be taken to avoid the pollution of streams and farm ponds stocked with fish when excess spray or dust materials are being disposed of or when equipment is being cleaned. There is comparatively less hazard to game animals and birds than to fish.

Additional safeguards.--Equipment which has been used for mixing and applying 2,4-D and other hormone-type weed killers should not be used for mixing and applying insecticides because of danger of crop injury. Containers sometimes become contaminated with 2,4-D or 2,4,5-T, and their re-use might prove very costly to the processor and to the farmer.

For stability in storage and to prevent breakdown of the emulsifiable concentrate formulations, metal containers should be lined with some material that will not react with the concentrate. It is not desirable to re-use metal containers for the packaging of emulsifiable concentrates.

Formulations

Most of the insecticides and miticides commonly used for control of cotton pests may be readily formulated into either sprays or dusts. Stable formulations of some materials have proved very difficult to make. Research on formulation is continually providing more satisfactory materials with greater stability. Farmers should use the particular formulation that has proved most effective.

Dusts.--Most organic insecticides and miticides are commonly used in dusts with talc, clay, calcium carbonate, pyrophyllite, diatomaceous earth, or sulfur as the carrier. The value of formulations with proper dusting characteristics cannot be overemphasized. Erratic results and poor control are sometimes due to inferior formulations, although frequently poor results due to improper application or timing are blamed on formulations. Much progress has been made in regard to formulations, but it is in the interest of insecticide conservation and insect control to continue to improve and standardize dust formulations. Some dusts containing high percentages of sulfur have undesirable dusting properties and may present a fire hazard. The incorporation of sulfur frequently helps to control spider mites.

Sprays.--Cotton insect and spider mite control has been highly successful when properly formulated sprays have been applied at rates ranging from 1 to 15 gallons per acre. Most of the organic-insecticide sprays used on cotton are made from emulsifiable concentrates. Occasional foliage injury has resulted from poorly formulated emulsions, or when the spray was improperly applied. Most oil solutions of insecticides cause foliage injury and therefore are not recommended. Emulsifiers and solvents should be tested for phytotoxicity before they are used in formulations. Phytotoxicity of emulsions may be aggravated by high temperatures, high concentrations, and dry winds.

Granules and fertilizer-insecticide mixtures.--Granulated formulations of insecticides and mixtures of insecticides and fertilizers are promising for control of soil insects. They are being used for white-fringed beetle and wireworm control in some areas. Such formulations of some systemic insecticides have shown promise against certain foliage-feeding pests.

Combinations of two or more insecticides.--Where more than one insect or mite is involved in a control program, insecticides are frequently combined to give control of the species involved. Bollworm and spider mite build-up frequently follows application of some insecticides, and for this reason DDT and sulfur are added to some dust formulations. DDT alone may be added to sprays of these insecticides as a precaution against bollworm outbreaks.

Where an outbreak of aphids or spider mites is involved, one of the recommended organophosphorus insecticides may be used alone or formulated with a boll weevil-bollworm formulation at the proper dosage.

Emulsifiable concentrates of two or more insecticides may be formulated into recommended sprays in the field. When this is done, however, the quantity of solvent is necessarily increased which may in turn increase the phytotoxicity hazard.

Mixtures containing partial dosages of several insecticides have frequently been unsatisfactory and are not recommended.

Applications

Insecticides may be applied to cotton with either ground or aerial equipment. Generally sprays and dusts are equally effective. Regardless of equipment chosen, effective control is obtained only when applications give thorough coverage and are properly timed. Improper or unnecessary applications may result in a pest complex that can cause greater damage to the cotton crop than the insect that originally required control.

Ground application.--High-clearance rigs make possible efficient application in rank cotton with little mechanical injury to plants. Ground machines should be calibrated to apply the proper dosage for the speeds at which they will be operated.

For dust applications the nozzles should be adjusted to approximately 10 inches above the plants, with one nozzle over each row. Dusts should not be applied when the wind velocity exceeds 5 miles per hour. Dusts are usually applied at 10 to 20 pounds to the acre except in the Far West, where heavier dosages are required.

For spraying seedling cotton it is suggested that one nozzle per row be used. As the cotton grows the number should be increased to three and in rank growth to as many as five or six. Nozzles without drops spaced 20 inches apart on the boom are used in some areas for mid- and late-season control.

The nozzles should be adjusted to approximately 10 inches from the plants, and be capable of delivering from 1 to 15 gallons per acre. Sprays may be applied at wind velocities up to 15 miles per hour.

Emulsifiable concentrates should be diluted immediately before use with not more than an equal volume of water. The emulsion should then be added to the required volume of water. Some type of agitation, generally the by-pass flow, is necessary during the spray operation to insure a uniform mixture.

As a safety measure it is recommended that the spray boom be located behind the operator.

Aerial application.--In aerial applications the swath width should be limited to the plane's wing span, or not more than 40 feet. When insect populations are extremely heavy, it may be advantageous to narrow the swath width. A method of flagging or marking should be used to secure proper distribution of the insecticide.

Properly formulated dusts of free flowability should be used to obtain even distribution. Applications should not be made when the wind velocity exceeds 4 miles per hour.

Emulsifiable concentrates should be mixed with water to the desired dilution immediately before use. Planes should be equipped with standard nozzles or other atomizing devices that will produce droplets within the range of 100 to 300 microns. They should be equipped to deliver from 2 to 10 gallons per acre depending on local conditions. Sprays may be applied at wind velocities up to 8 miles per hour. Pesticides in sprays that are strictly contact in action and that are to be directed against pests which are confined to the under surface of the leaves cannot adequately be applied to cotton by aircraft.

Timing of applications.--Correct timing is essential for satisfactory cotton-insect control. Consideration must be given to the over-all populations and stages of both beneficial and harmful insects rather than to those of a single pest. The stage of growth of the cotton plant and expected yield are important.

Most insecticides kill predatory and parasitic insects as well as pest insects. Since the use of insecticides often induces outbreaks of aphids, bollworms, and spider mites, they should be applied only where and when needed.

Early-season applications should be made to control aphids, beet armyworm, cutworms, darkling ground beetles, grasshoppers, or other insects which threaten to reduce a stand. Recommendations for early-season applications against the boll weevil, the cotton fleahopper,

plant bugs, and thrips vary greatly from State to State. Differences in infestations of these insects as well as many other production factors make it undesirable to attempt to standardize recommendations for early-season control.

It is likewise generally recommended that suitable insecticides be applied to cotton during its maximum period of fruiting and maturing of the crop, if infestations threaten to reduce the yield, seriously affect quality, or delay maturity. Recommendations for insecticide treatments are similar throughout the Cotton Belt, but certain details differ from State to State, and often within a State.

Resistance to Insecticides

Resistance to insecticides is the ability in insect strains to withstand exposure to an insecticide which exceeds that of a normal susceptible population, such ability being inherited by subsequent generations of the strain.

Resistance of cotton pests to insecticides has developed rapidly in recent years. Since 1947 when organic chemicals began to have wide usage on cotton, 17 species of insects and spider mites which attack the crop are known to have developed resistance and 4 other species are strongly suspected of having developed resistance to them. One or more of these resistant species occur in localized areas in 10 of the 14 cotton-growing States from California to North Carolina. In most cases the pests are resistant to the chlorinated hydrocarbon insecticides but 4 species of mites are known to be resistant to organophosphorus compounds and another is strongly suspect.

Resistance of most species continues to be restricted to relatively small areas and no species is known to be resistant throughout the range of its occurrence. However, the boll weevil is known to be resistant in localized areas of 8 of the 11 States in which it occurs from Texas to North Carolina, and resistance is suspected in 1 other.

The following is a tabulation of the pests known to be resistant to certain insecticides in the various States:

Pest	Insecticides	States
Beet armyworm	DDT	California, Arizona
Boll weevil	Chlorinated hydrocarbons	Alabama, Arkansas, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas
Brown stink bug	DDT	California
Cabbage looper	DDT	Arkansas, California, Louisiana, Oklahoma, Texas
Cotton aphid	BHC (gamma)	All cotton producing States
Cotton fleahopper	Chlorinated hydrocarbons	Texas
Cotton leaf perforator	DDT	Arizona
Cotton leafworm	Chlorinated hydrocarbons	Texas
Lygus bugs (2 spp.)	DDT	Arizona, California
Salt-marsh caterpillar	Toxaphene, DDT	Arizona, California
Spider mites (4 spp.)	Organophosphorus	Arizona, California
Southern garden leafhopper	DDT	California
Thrips	Chlorinated hydrocarbons	Texas

Resistance of cotton pests to recommended insecticides is a serious problem. It emphasizes the importance of using every known means possible to alleviate the difficulty to the extent that control may be maintained. This includes the use of pesticides having different physiological modes of action than those to which resistance has been developed and of cultural control, especially early stalk destruction, in reducing populations of the boll weevil, the pink bollworm, and other insects where such methods are applicable. Every advantage possible should be taken of biological control agents and where there is a choice, chemicals that are of minimum detriment to beneficial insects should be used.

Effect of Environmental Factors on Insect Control

Failures to control insects have often been attributed to ineffective insecticides, poor formulations, and poor applications. Recently, resistance has been blamed for failures in local areas. Extremes of humidity, rainfall, temperature, sunlight, and wind have been shown to reduce the toxicity of an insecticide applied to plants. These factors also affect the development of insect populations, being favorable to certain species and detrimental to others. The rate and total growth of the plant are also affected by these factors, particularly if the same conditions last for several days or weeks. Inability to maintain a regular application schedule due to excessive rains or high winds often results in loss of control at a critical period.

A combination of an adverse effect on the toxicity of the insecticide plus a favorable effect on growth of the plant and insect population may result in failure to obtain control. Conversely, conditions favorable to the insecticide and plants and adverse to the insect population will result in very effective control. High rates of fertilizer and supplemental irrigation although valuable in cotton production programs may create conditions which make insect control difficult. Also, many insects, particularly the boll weevil, become more difficult to kill as the season progresses. Therefore, one should consider all factors before arriving at a decision as to the specific factors responsible for the failure to obtain control.

Recommended Materials

Aldrin

Aldrin in a dust or spray will control the boll weevil, the cotton fleahopper, grasshoppers, lygus bugs, the rapid plant bug, the tarnished plant bug, and thrips. (See statement on resistance, page 14). It will not control the cotton aphid, spider mites, and most lepidopterous larvae including the bollworm, the cotton leafworm, certain species of cutworms, the garden webworm, the pink bollworm, and the yellow-striped armyworm. The use of aldrin and mixtures of aldrin and DDT may result in increased populations of aphids and spider mites. For boll weevils, aldrin should be applied at the rate of 0.25 to 0.75 pound per acre, and when bollworms are also a problem 0.5 to 1.5 pounds of DDT should be added.

Aldrin (plus a fungicide) dusted or slurried onto seed at the rate of 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from false wireworms, seed-corn maggot, and wireworms.

Aldrin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Insecticides and Miticides Useful or Showing Promise for the Control of Cotton Pests

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
Recommended Materials		
Aldrin	Delnav	Aramite
BHC	Demeton (Systox)	Calcium arsenate
DDT	Diazinon	Dilan
Dieldrin	Dibrom	Sevin
Endrin	Dipterex	Sulfur
Heptachlor	Ethion	Tedion
Kelthane	Guthion	
Strobane	Malathion	
Toxaphene	Methyl parathion	
	Parathion (ethyl parathion)	
	Trithion	
Materials showing promise in field tests		
Shell SD-4402	Bayer 29493	Bacillus thuringiensis
	Methyl trithion	
	Shell SD-3562	Barthrin
Materials showing promise in cage and/or laboratory tests		
	Bayer 30911	
	Ronnel (Korlan)	
	Shell SD-4092	
	Velsicol 53-CS-17	
Materials found effective but seldom used on cotton insects [1/]		
Chlordane	Di-Syston (Bayer 19639)	Cryolite
Lindane	EPN	Lead arsenate
Methoxychlor	Phorate (Thimet)	Nicotine
Ovex	Phosdrin	Paris green
	TEPP	Rotenone
		Thiodan

1/ For information on these materials, see earlier reports 1 through 12.

Aramite

Aramite in a dust or spray will control spider mites when applied at 0.3 to 1 pound per acre. Two applications 5 to 7 days apart may be required. Erratic results have been reported from some areas. Care should be used in the preparation of formulations to insure stability. Aramite has essentially no insecticidal activity. The acute toxicity of aramite to warm-blooded animals is relatively low, but the potential hazard from a chronic standpoint is very high.

See Hazards and Precautions in the Use of Insecticides.

BHC

BHC in a dust or spray will control the boll weevil, the cotton aphid, the cotton fleahopper, the fall armyworm, the garden webworm, grasshoppers, lygus bugs, the rapid plant bug, stink bugs, and thrips. (See statement on resistance, page 14). It will not control the bollworm, some species of cutworms, the pink bollworm, the salt-marsh caterpillar, spider mites, or the yellow-striped armyworm. It has given erratic results against the cotton leafworm, and it has failed to control the cotton aphid in some areas.

Except for use in early-season control, BHC is usually formulated with DDT in the ratio of 3 parts of the gamma isomer to 5 parts of DDT in both dusts and sprays. Depending upon the insects to be controlled, this mixture should be applied at rates ranging from 0.3 to 0.45 pound of the gamma isomer and 0.5 to 1 pound of DDT per acre. In some of the western areas a standard formulation has been 2 parts of the gamma isomer to 5 parts of DDT. Where spider mites are a problem, the dust usually contains at least 40 percent of dusting sulfur. Other dusts contain either 2 or 3 percent of the gamma isomer of BHC and 10 percent of DDT and are usually preferred in areas where the bollworm or pink bollworm is the dominant problem. Sprays should be formulated to contain the same amount of each active ingredient as the dusts. It is very important that the emulsifiable concentrate containing BHC be properly formulated to prevent foliage or plant injury.

It is not advisable to use BHC on cotton that will be in rotation with some root crops.

BHC is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Calcium Arsenate

Calcium arsenate will control the boll weevil and the cotton leafworm. It has excellent dusting qualities and should be used at the rate of 7 to 15 pounds per acre. Against bollworms it will give fair control at 12 to 15 pounds per acre if applications are properly timed. Generally it is used undiluted against these insects. It often causes an increase in aphid population when used without an aphicide. Alternate applications of calcium arsenate and methyl parathion or malathion have given excellent results against the boll weevil and the cotton aphid in some areas.

Calcium arsenate manufactured so as to contain relatively little free lime is compatible with organic insecticides; however, some commercial sources of so-called low-lime calcium arsenate have not been compatible with certain of them. When a mixture containing calcium arsenate, 5 percent of DDT, and 1 percent of parathion is used (see precautions under Parathion), boll weevil, bollworms, cotton aphid, some spider mites, and certain other pests are controlled. Low-lime calcium arsenate in combination with these materials should be applied at the rate of 10 to 12 pounds per acre.

High suspensible calcium arsenates have been developed for spraying. In field tests conducted in Arkansas for 3 years, 7 to 10 pounds of these high suspensible materials in 10 to 15 gallons of water per acre gave results comparable to those obtained with regular calcium arsenate dusts in controlling the boll weevil. Several farmers in Arkansas sprayed calcium arsenate successfully in 1958 and 1959. Promising results were also obtained in Louisiana. Care in mixing and applying combined with good agitation are necessary to avoid excessive nozzle stoppage and line and pump wear.

Calcium arsenate residue in the soil is injurious to some crops, especially legumes and oats in certain sandy soils. It should not be used in fields where rice may be planted. Drifting of the dust may injure other crops, especially rice, soybeans, pecans, and peaches. Care should be taken to avoid drift that might cause bee losses, or onto pastures, especially when applications are made by airplane. Livestock should be kept out of treated fields.

Calcium arsenate is moderately toxic to man and animals and should be used with adequate precautions. It is extremely hazardous to livestock grazing on contaminated feed or forage.

See Hazards and Precautions in the Use of Insecticides.

DDT

DDT in a dust or spray will control the bollworm, the cotton fleahopper, the darkling ground beetle, the fall armyworm, flea beetles, the garden webworm, the leaf roller Platynota stultana, lygus bugs, the pink bollworm, the tobacco budworm, thrips, the western yellow-striped armyworm, and the white-lined sphinx. (See statement on resistance, page 14). DDT will also control certain species of cutworms, and to a lesser extent the yellow-striped armyworm. Unsatisfactory results against thrips have been reported when the temperature exceeded 90° F.

A mixture of DDT at 1 pound and toxaphene or Strobane at 2 pounds per acre in a spray will control resistant boll weevils. A toxaphene-DDT dust mixture in the same ratio has been effective for control of resistant boll weevils over a two-year period in North Carolina.

DDT will not control the cabbage looper, the cotton aphid, the cotton leafworm, grasshoppers, the salt-marsh caterpillar, spider mites, or stink bugs in the genera Chlorochroa, Euschistus, and Thyanta.

DDT is ordinarily used at the rate of 0.5 to 3 pounds per acre, either alone or mixed with other insecticides or miticides.

Aphid and mite populations may increase until they cause severe injury where DDT is used, unless an aphicide or a miticide is included in the formulation.

DDT is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Delnav

Delnav in a spray will control the cotton leafworm at 0.25 to 0.5 pound per acre. Control of cotton aphids and spider mites at 0.4 to 0.6 pound per acre in sprays has been erratic. In California it failed to control leaf rollers at 0.25 to 0.5 pound per acre.

Delnav is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Demeton (Systox)

Demeton, the principal active ingredient in Systox, is both a contact and a systemic insecticide with a long residual activity. When applied in a foliage spray at 0.125 to 0.4 pound per acre, it is effective against cotton aphids and spider mites for 2 to 8 weeks, and shows promise for control of the southern garden leafhopper. (See statement on resistance, page 14). It does not control the boll weevil, the bollworm, the cotton leafworm, grasshoppers, or the pink bollworm.

Demeton is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Diazinon

Diazinon in a spray will control the cotton aphid at 0.25 pound per acre. It also appears promising for the control of leafhoppers (Empoasca spp.) and spider mites at dosages between 0.125 and 0.5 pound, and is effective against the cotton leaf perforator at 0.5 pound per acre.

Diazinon is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Dibrom (Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate)

Dibrom in a dust or spray will control the cotton leaf perforator and lygus bugs at 0.5 pound per acre but is ineffective against the cabbage looper and spider mites at this dosage. It appears promising against the bollworm in some areas.

Dibrom is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Dieldrin

Dieldrin in a spray or dust will control the boll weevil, the cotton fleahopper, the black cutworm, the granulate cutworm, the pale-sided cutworm, the variegated cutworm, field crickets, the garden webworm, grasshoppers, lygus bugs, the rapid plant bug, stink bugs, thrips, and the yellow-striped armyworm. (See statement on resistance, page 14). It is not effective against bollworms and the salt-marsh caterpillar at dosages usually recommended for the boll weevil. Aphids

and spider mites may increase where dieldrin is used. Against boll weevils dieldrin should be applied at the rate of 0.15 to 0.5 pound per acre and when bollworms are a problem 0.5 to 1.5 pounds of DDT should be added. Dieldrin will kill newly hatched cotton leafworms at dosages effective against the boll weevil.

Dieldrin (plus a fungicide) dusted or slurried onto seed at the rate of 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from seed-corn maggots, false wireworms, and wireworms.

Dieldrin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Dilan

Dilan in a spray will control the cotton leaf perforator, lygus bugs, and the salt-marsh caterpillar at 0.6 to 1.5 pounds per acre. It is not effective against the boll weevil, the cotton aphid, spider mites, or stink bugs.

Dilan is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Dipterex (Dylox)

Dipterex as a spray will control the cotton aphid and the cotton leafworm at 0.25 to 1 pound; the beet armyworm, the brown stink bug, the leaf roller Platynota stultana, and lygus bugs at 1 to 1.5 pounds; the western yellow-striped armyworm at 0.5 pound; cotton leaf perforator and stink bugs at 0.75 to 1.5 pounds; and the salt-marsh caterpillar at 1.5 pounds per acre. It is effective against pink bollworm moths, but not against larvae at 2 pounds per acre.

Dipterex has given erratic results against bollworms and the cabbage looper. It was not effective against the cotton fleahopper and thrips at 0.5 to 1 pound per acre.

In some instances dipterex has been phytotoxic.

Dipterex is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Endrin

Endrin in a spray or dust will control the boll weevil, the bollworm, the brown cotton leafworm, the cabbage looper, the greenhouse or celery leaf tier, the cotton leafworm, cutworms, the fall armyworm, the garden webworm, grasshoppers, lygus bugs, and the tobacco budworm when applied at 0.2 to 0.5 pound per acre in most areas. The cotton fleahopper and thrips are controlled at 0.08 to 0.15 pound. (See statement on resistance, page 14). It has not given satisfactory control of bollworms, cabbage loopers, and salt-marsh caterpillars in Arizona. Some failures against the bollworm at 0.2 pound per acre were reported from South Carolina. It will not control the pink bollworm or spider mites. Aphids usually do not build up after use of endrin, but spider mites sometimes do.

Endrin (plus a fungicide) dusted or slurried onto seed at 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from false wireworms, seed-corn maggots, and wireworms.

Endrin is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Ethion

Ethion in a dust or spray at 0.5 to 1 pound per acre will control the cotton aphid, lygus bugs, and the strawberry (Atlantic), carmine, desert, lobed, tumid, and two-spotted spider mites.

Ethion is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Guthion

Guthion in a dust or spray at 0.25 to 0.5 pound per acre will control the boll weevil, the brown cotton leafworm, the cotton fleahopper, the cotton leafworm, the garden webworm, and thrips. Erratic results have been obtained against the cotton aphid, lygus bugs, and spider mites. It is ineffective against the beet armyworm and the salt-marsh caterpillar.

Guthion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Heptachlor

Heptachlor in a spray or dust will control the boll weevil, false chinch bugs, the garden webworm, grasshoppers, lygus bugs, and stink bugs at dosages ranging from 0.25 to 1 pound per acre. The field cricket may be controlled with a 5 percent heptachlor dust applied at 20 pounds per acre. (See statement on resistance, page 14). When bollworms are a problem, 0.5 to 1.5 pounds of DDT should be added. It is effective against the cotton fleahopper and thrips at dosages from 0.08 to 0.25 pound per acre. It will not control the bollworm, the cotton aphid, the pink bollworm, spider mites, or the yellow-striped armyworm. Aphid and spider mite populations may increase where heptachlor or a heptachlor-DDT mixture is used. Research over a three-year period showed that two applications annually of 5 percent heptachlor granules, properly timed, at the rate of 40 pounds per acre controlled the boll weevil until late in the season in Alabama. However, unsatisfactory results were obtained in resistant areas in 1959. Such treatments were ineffective in Louisiana and South Carolina.

Heptachlor (plus a fungicide) dusted or slurried onto seed at 1 to 2 ounces per 100 pounds immediately before planting will protect seed and young seedlings from false wireworms, seed-corn maggots, and wireworms.

Heptachlor is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Kelthane

Kelthane is an acaricide with little insecticidal activity. At 1 pound per acre in a spray or dust it will control some species of spider mites. For best results sprays should be applied at a minimum of 20 gallons per acre. Kelthane sprays applied from airplanes gave erratic results.

Kelthane is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Malathion

Malathion in a spray at 0.5 to 2 pounds per acre will control the boll weevil and the cotton aphid and at 0.25 to 1 pound will control black fleahoppers, the brown cotton leafworm, the cotton fleahopper, the cotton leaf perforator, the cotton leafworm, leafhoppers, lygus bugs, and thrips. Results against whiteflies have

been erratic at these dosages. It will not control the bollworm and the salt-marsh caterpillar. Where the bollworm is a problem 0.5 to 1.5 pounds of DDT should be added to dosages used for control of other pests. In some areas 0.5 pound of malathion at 3-day intervals gave boll weevil control comparable to that obtained at 4- to 5-day intervals with higher dosages. It has given poor results against most spider mite species. Dust formulations have not been entirely satisfactory in some areas, probably due to instability.

Malathion is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Methyl Parathion

Methyl parathion in a dust or spray at 0.25 to 0.75 pound per acre will control the boll weevil, the cotton aphid, the cotton leaf perforator, the cotton leafworm, thrips, and some species of spider mites, but it has a short residual toxicity. For late-season boll weevil control a dosage of 0.25 pound at 3-day intervals is preferred over higher dosages at longer intervals. It is not effective against the bollworm and the pink bollworm. Although it is unsatisfactory for control of most species of spider mites, methyl parathion in a boll weevil schedule usually suppresses them. When bollworms are a problem 0.5 to 1.5 pounds of DDT should be added. Dust formulations have not been entirely satisfactory in some areas probably due to their instability.

Methyl parathion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Parathion (ethyl parathion)

Parathion in a dust or spray will control the brown cotton leafworm, the cotton aphid, the cotton leaf perforator, the cotton leafworm, the garden webworm, leafhoppers, the salt-marsh caterpillar, some species of spider mites, and stink bugs at 0.1 to 1 pound per acre. Repeated applications at 1 pound per acre will control the leaf roller Platynota stultana. It gives very little control of the boll weevil, the bollworm, the fall armyworm, the pink bollworm, the variegated cutworm, or whiteflies.

Parathion is extremely toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Sevin

Sevin in a dust or wettable powder spray will control the boll weevil, the bollworm, the cotton leaf perforator, the pink bollworm, and the salt-marsh caterpillar at 1 to 2.5 pounds per acre and the cotton fleahopper, the cotton leafworm, and thrips at 0.5 to 1 pound per acre. It does not control the beet armyworm, the black fleahopper complex, Nysius raphanus, spider mites, and stink bugs. It is highly toxic to honey bees. Aphids do not usually build up following its use.

Sevin is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Strobane

Strobane in a dust or spray will control the boll weevil, the cotton leafworm, the cotton leaf perforator, the garden webworm, stink bugs, and lygus bugs at 2 to 4 pounds per acre. Although Strobane has been used for control of the bollworm at 2 to 4 pounds per acre, other materials have given more satisfactory results. It will control the cotton fleahopper and thrips when applied at 0.75 to 1 pound per acre. (See statement on resistance, page 14). It will not control the salt-marsh caterpillar. Control of the boll weevil and the bollworm is improved when DDT at 0.25 to 1 pound per acre is included with the Strobane spray. A mixture of Strobane at 2 pounds and DDT at 1 pound per acre will control resistant boll weevils. Its use may result in a build-up of cotton aphid and spider mite populations.

Strobane is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Sulfur

Sulfur has been widely used in dust mixtures for control of the cotton fleahopper and certain species of spider mites. Where the desert spider mite is a problem and for all spider mite species in Arizona, at least 40 percent of sulfur should be included in all dusts to prevent or suppress infestations. It will not control the Pacific or the two-spotted spider mite in most areas. In California excellent control of the strawberry spider mite has been obtained with sulfur at 25 to 30 pounds per acre. Sulfur is most effective when finely ground and when the temperature is 90° F. or above. Precautions should be exercised in applying it to cotton adjacent to cucurbits.

Tedion

Tedion in a dust or spray at 0.1 to 1 pound per acre will control the carmine, Pacific, and two-spotted spider mites. This material is very slow in action at temperatures below 90° F. and appears to have long residual properties. It has little insecticidal activity.

Tedion is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Toxaphene

Toxaphene in a dust or spray will control the boll weevil, the cotton leafworm, the cotton leaf perforator, cutworms, the fall armyworm, the garden webworm, grasshoppers, and lygus bugs when applied at dosages from 1 to 5 pounds per acre. At 4 pounds per acre it will give fair to good control of stink bugs. It will control the cotton fleahopper and thrips when applied at 0.75 to 1 pound per acre. (See statement on resistance, page 14). Although toxaphene has been used for control of the bollworm at 2 to 4 pounds and the yellow-striped armyworm at 2 to 3 pounds per acre, other materials have given more satisfactory results. Toxaphene will not control cabbage loopers, the pink bollworm, and salt-marsh caterpillars.

Control of the boll weevil, bollworm, the cotton leaf perforator, and the tobacco budworm is improved where DDT at 0.25 to 1 pound per acre is incorporated in the toxaphene spray. A mixture of toxaphene at 2 pounds and DDT at 1 pound per acre in a spray will control resistant boll weevils. The use of this mixture frequently results in cotton aphid and spider mite build up. The toxaphene-DDT dust mixture in the same ratio has been effective for control of resistant boll weevils over a two-year period in North Carolina.

Toxaphene is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Trithion

Trithion in a dust or spray at 0.25 to 1 pound per acre will control the cotton aphid and spider mites and appears to have long residual activity. At 1 pound per acre it is effective against the cotton leaf perforator and showed some promise against the boll weevil. It was not effective against the bollworm, cabbage looper, lygus, or stink bugs, and was erratic against salt-marsh caterpillars. A dust mixture containing 4 percent Trithion and 5 percent DDT applied at 20 pounds per acre gave good boll weevil control in 1958 and 1959 in Alabama.

Trithion is extremely toxic to man and animals if taken internally and moderately toxic by skin contact; it should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Materials Showing Promise in Field Tests

Bacillus thuringiensis

The pathogen Bacillus thuringiensis has shown some promise for cotton leafworm control in a field test in Texas. It has not shown promise against the cabbage looper, cotton leaf perforator, or salt-marsh caterpillar in field tests in California but was effective against the salt-marsh caterpillar in Arizona.

Available data indicate little or no hazard associated with the use of this pathogen; however, since it is an experimental material ordinary precautions are recommended in connection with its use.

See Hazards and Precautions in the Use of Insecticides.

Barthrin (6 Chloropiperonyl chrysanthemumate)

Barthrin was promising against boll weevil and pink bollworm at 2 pounds per acre. If proved highly effective, it would have a potential value against resistant strains since its mode of action is probably different than that of either the chlorinated hydrocarbons or phosphorus compounds.

Barthrin is less toxic to man and animals than many of the other insecticides in common use but it should be handled with caution.

See Hazards and Precautions in the Use of Insecticides.

Bayer 29493 (O,O-Dimethyl 4-methylthio-m-tolyl phosphorothioate)

In field tests Bayer 29493 was effective against the pink bollworm at 1 pound per acre and against the boll weevil at 0.5 pound per acre.

Bayer 29493 is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Methyl trithion

In field tests this material was promising against lygus bugs at 1 pound and against boll weevils at 0.5 pound per acre.

The toxicity of this compound is not fully known so extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Shell SD-3562 (Dimethyl 1-(dimethylcarbamoyl)-1-propen-2-yl phosphate)

Shell SD-3562 in a spray showed promise against the cotton leafworm at 0.25 pound, the cotton aphid and thrips at 0.2 to 0.5 pound, the desert spider mite at 0.5 pound, the carmine spider mite at 0.125 to 0.25 pound, and the boll weevil at 1 pound per acre. It was ineffective against bollworms at 1 pound per acre.

The toxicity of this compound is not fully known but extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Shell SD-4402 (1,3,4,5,6,7,8,8-Octachloro-3a,4,7,7a-tetrahydro-4,7-methanoiso benzofuran)

Shell SD-4402 in field tests in a spray showed promise against thrips at 0.25 pound, the cotton leafworm at 0.5 pound, the boll weevil at 0.5 to 1 pound, and the bollworm, cotton leaf perforator, lygus bugs, and the black fleahopper complex at 0.25 to 1 pound per acre. It was ineffective against the pink bollworm at 0.5 to 1 pound per acre.

The toxicity of this compound is not fully known but extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Materials Showing Promise in Cage and/or Laboratory Tests

Bayer 30911 (Phosphonothioic acid, methyl-,O-2,4-dichlorophenyl O-methyl ester)

In laboratory and cage tests this material showed promise against the boll weevil at 0.25 pound per acre.

The toxicity of this compound is not fully known so extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Ronnel (Korlan)

This material was mentioned in the report for 1956 under the designation of Dow ET-15. In 1959 it showed promise in laboratory tests against lygus bugs at 1 pound per acre.

Ronnel is moderately toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides.

Shell SD-4092 (Phosphoric acid, 1-benzyloxycarbonyl-1-propen-2-yl dimethyl ester)

This material was promising in cage tests against the boll weevil at 0.5 pound per acre.

The toxicity of this compound is not fully known so extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

Velsicol 53-CS-17 (1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-Methanoindan)

This material was effective in laboratory tests against pink bollworm adults at 2 pounds per acre and had a long residual activity.

The toxicity of this compound is not fully known so extreme caution should be observed in its use.

See Hazards and Precautions in the Use of Insecticides.

CULTURAL PRACTICES

The development of resistance by cotton insects makes good cultural practices imperative. Certain cultural practices reduce and under some conditions may even eliminate the need for insecticides. Several of these practices can be followed by every cotton grower, whereas others are applicable only to certain areas and conditions. Growers following these practices should continue to make careful observations for insects and apply insecticides when needed.

Early Stalk Destruction

The boll weevil resistance problem emphasizes the urgent need for early destruction of cotton stalks. The destruction or killing of cotton plants as early as possible before the first killing frost prevents further population build-up and forces the boll weevil into starvation before it goes into winter quarters. The earlier the weevils are deprived of a food supply the less chance they have of surviving the winter. Early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem the following season, especially in the southern part of the Cotton Belt.

Early stalk destruction and burial of infested debris are generally the most important practices in pink bollworm control. Modern shredders facilitate early stalk destruction and complete plow-under of crop residues. The shredding operation also kills a high percentage of pink bollworms left in the field after harvest. The flail type shredder is recommended over the horizontal rotary type for pink bollworm control. Plowing under the crop residue as deeply as possible after the stalks are cut will further reduce the pink bollworm survival. The use of these machines should be encouraged as an aid in the control of both the boll weevil and the pink bollworm. Heavy grazing after harvest is very effective in reducing the overwintering pink bollworm population. See precautions on grazing late treated fields, page 8 of this report.

Stub or Volunteer Cotton

Stub, volunteer, and abandoned cotton contributes to insect problems because the stalks and undisturbed soil provide a place for insects to live through the winter. This is especially true with regard to the cotton leaf perforator and the pink bollworm. Volunteer cotton is also the principal overwinter host for the leaf crumple virus of cotton in the southwestern desert areas and for its whitefly vector. All cotton plants should be destroyed soon after harvest.

Planting

Uniform planting of all cotton within a given area during a short period of time will reduce concentration of insects in early fields. A wide spread in planting dates tends to increase populations of boll weevil, pink bollworm, and possibly other insects. Planting during the earliest optimum period for an area also makes earlier stalk destruction possible.

Skip Row Planting

The practice of skip row planting has changed some of the aspects of insect control on cotton. Insects such as cutworms and garden webworms that feed on weeds allowed to grow in these strips may move into the cotton when such weeds are destroyed by cultivation. The strip cropping practice facilitates the use of ground equipment. However, applications by airplane become more expensive since the entire field must be treated and only half of it is planted to the crop.

Varieties

Varieties of cotton that bear prolifically, fruit early, and mature quickly may set a crop before the boll weevil and other insects become numerous. This is especially true when other cultural control practices are followed.

Soil Improvement

Fertilization, rotation of crops, and plowing under of green manure crops are good farm practices and should be encouraged. Although fertilization and crop rotations do not usually contribute directly to insect control, the higher yields give higher returns from the use of insecticides. Over-fertilization, especially with nitrogen, may unnecessarily extend the period during which insecticidal protection is necessary. Likewise, under-fertilization may nullify gains expected from insecticides. The fact that a number of insects and spider mites attack legumes and then transfer to cotton should not discourage the use of legumes, as insect pests may be controlled on both these crops.

Other Host Plants of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of cotton insects. In many cases control measures should be applied to other hosts to prevent migration to cotton. Thrips breed in onions, potatoes, carrots, legumes, small grains, and some other crops. They later move in great numbers into adjacent or interplanted cotton. Beet armyworms, garden webworms, lygus bugs, stink bugs, variegated cutworms, western yellow-striped armyworms, and other insects may migrate to cotton from alfalfa and other plants. The cotton fleahopper migrates to cotton from horsemint, croton, and other weeds. Spider mites spread to cotton from many weeds and other host plants adjacent to cotton fields.

Hibernation Areas

The boll weevil hibernates in well-drained, protected areas in and near cotton fields. Spider mites overwinter on low-growing plants in or near fields. Small patches of weeds near fields, along turnrows and fences, or around stumps and scattered weeds in cultivated fields or pastures should be destroyed. Such practices are more effective where the cotton acreages are in sizable blocks than in small patches. General burning of ground cover in woods is not recommended.

Seed cotton scattered along turnrows, loading areas, and roadsides serves as a source of pink bollworm carry-over to the next crop, and should be cleaned up. To minimize this hazard, trucks, trailers, and other vehicles in which the seed cotton is being hauled to the gin should be covered.

Gin-plant sanitation should be practiced to eliminate hibernating quarters of the boll weevil and the pink bollworm on such premises. In areas where pink bollworms occur, State quarantine regulations require that gin trash be burned, sterilized, run through a hammer mill or fan of specified size and speed, composted, or given some other approved treatment.

CHEMICAL DEFOLIATION AND DESICCATION AS AN AID TO INSECT CONTROL

Chemical defoliation and desiccation of cotton aid in the control of many cotton insects. These practices check the growth of the plants and accelerate the opening of mature bolls, reducing the damage and the late-season build-up of boll weevils and pink bollworms which would otherwise remain to infest next year's crop. They also prevent or reduce damage to open cotton by heavy infestations of aphids, the cotton leafworm, and whiteflies. Stalks should be destroyed and other cultural practices followed, as discussed under "Early Stalk Destruction," after harvest in areas where regrowth is likely to occur before frost or spring plowing.

Defoliation or desiccation permits earlier harvesting and better use of mechanical harvesters. This also permits earlier destruction of the stalks, an important aid in the control of the pink bollworm and the boll weevil. However, if losses in yield and quality are to be avoided, defoliants and desiccants should not be applied until all bolls that are to be harvested are mature.

Guides for the use of different defoliants and desiccants, developed by the Defoliation Conference, have been issued by the National Cotton Council of America, Memphis, Tenn. They contain information concerning the influence of plant activity, stage of maturity, and effect of environment on the efficiency of the process, and give details relative to the various needs and benefits. They explain how loss in yield and quality of products may be caused by improper timing of the applications. These guides are based on broad ecological areas rather than on State boundaries. Local and State recommendations should be followed.

PRODUCTION MECHANIZATION IN COTTON-INSECT CONTROL

Increased mechanization in cotton production makes tractors available for efficient application of insecticides. High-clearance sprayers and dusters have proved to be very useful and satisfactory for application of insecticides and defoliants, especially in rank cotton. Tractors also enable the grower to use shredders, strippers, mechanical harvesters, and larger and better plows, all of which help in the control of the pink bollworm and to some extent the boll weevil.

The flaming operation for weed control is of questionable value in insect control.

Mechanical harvesting with spindle type pickers may result in leaving more infested cotton in the field than hand picking, thus increasing the potential overwintering pink bollworm population. The use of strippers to harvest the crop is highly desirable from the standpoint of pink bollworm control because all bolls are stripped

from the plants and are transported to the gins where a high percentage of the larvae are killed in the ginning process. The use of desiccants or defoliants in preparing plants for harvesting usually prevents further plant growth and, consequently, the late-season build-up of populations of several insects.

Stalk shredders not only destroy certain insects, particularly the pink bollworm, but enable the cotton growers over wide areas to have the stalks destroyed before frost, and thereby stop the development of late generations of this insect and the boll weevil.

The increased use of mechanized equipment for cotton production has resulted in large acreages of uniform, even-age stands in some areas. Early-season boll weevil infestations are thus widely dispersed over the fields. Hibernation quarters in or immediately adjacent to the fields are frequently eliminated by these modern cultivation practices

Certification of mechanical cotton pickers and strippers moving from pink bollworm-infested to noninfested areas is required by quarantine regulations.

BIOLOGICAL CONTROL OF COTTON INSECTS

Predators, parasites, and diseases play an important role in the control of insect pests of cotton. Full advantage should be taken of these natural enemies, and the over-all pest-control program should include the maximum integration of natural, chemical, and cultural control. Wherever possible, an attempt should be made to evaluate the role of beneficial insects in the fields being checked.

Some predaceous insects of prime importance are: Orius, effective on thrips and other small insects as well as bollworm eggs, lacewings, effective on bollworm larvae and other soft bodied insects, Geocoris, Nabis and Zelus effective against mirids and other insects. Arthropod predators of importance under some circumstances are spiders, wasps, ladybird beetles, predaceous ground beetles and larvae of syrphid flies.

Parasites that are often effective against certain cotton pests include several wasplike species, ranging in size from extremely small

ones that develop in aphids and in the eggs of other insects to those as large as some of our common wasps, and several species of tachinid flies that resemble the house fly.

Thus far the importation and colonization of insect parasites of the pink bollworm and the boll weevil have not proved effective. On the other hand, native predators and parasites are often highly effective against aphids, the bollworm, cotton leafworm, cutworms, lygus bugs, spider mites, and whiteflies.

The release of the common ladybird beetles (Hippodamia spp.) has little practical value in the control of the pink bollworm or other cotton insects. Although they might destroy some eggs or immature stages of other pests, their attack is directed primarily toward aphids. These beetles occur so widely and are so abundant that the few that can be released add little to the local population. There is no evidence that the propagation and release of Trichogramma for bollworm control are of any economic value to the cotton growers.

A polyhedral virus sometimes substantially reduces cabbage looper and cotton leafworm populations in localized areas. The use of Bacillus thuringiensis in sprays and dusts is discussed on page 28.

MACHINES OF NO VALUE IN INCREASING YIELDS OF COTTON

Bug-catching machines.--Bug-catching machines are not recommended as a means of controlling cotton insects.

Electronic devices.--No recognized research agency has yet discovered any evidence that would support claims of effectiveness of so-called electronic devices for the control of insects in the field. Such devices are not recommended.

Light traps.--Light traps are useful for the purpose of survey and detection of certain insects but are of no value in controlling any cotton insect pest.

Recommended Dosages for the Principal Insecticides Used for the Control of Certain Cotton Pests

(Pounds per acre of technical material in a dust or emulsion spray)

Pesticide	Boll weevil	Boll-worm	Cotton aphid	Cotton flea-hopper	Cotton leafworm	Cutworms	Fall army-worm	Grass-hoppers	Lygus and other mirids	Pink boll-worm	Spider mites1/	Stink bugs	Thrips
Aldrin	0.25-0.75	--	--	0.25	--	--	--	0.10-0.25	0.25-0.75	--	--	--	0.08-0.15
BHC (gamma)	0.30-0.45	--	--	0.1	--	--	--	0.3-0.45	0.3-0.45	--	--	0.45	0.1-0.2
Calcium arsenate2/	7-15	--	--	--	7-10	--	--	--	--	--	--	--	--
DDT	--	0.5-2.0	--	0.5	--	1-2.53/	1.0-1.5	--	1.0-1.5	2-3	--	--	0.25-1.5
Demeton4/	--	--	0.125-0.4	--	--	--	--	--	--	--	0.25-0.4	--	--
Dieldrin	0.15-0.50	--	--	0.15	--	0.3-0.53/	--	0.07-0.125	0.15-0.50	--	--	0.5	0.08-0.15
Dipterex	--	--	0.25-1.0	--	0.25-1.0	--	--	--	1.0-1.5	--	--	1.5	--
Endrin	0.2-0.5	0.2-0.5	--	0.1	0.2-0.5	0.2-0.5	0.2-0.3	0.2-0.5	0.2-0.5	--	--	--	0.08-0.15
Guthion	0.25-0.50	--	--	0.25	0.25-0.5	--	--	--	--	--	0.25-0.5	--	0.25-0.5
Heptachlor	0.25-0.75	--	--	0.25	--	--	--	0.25-0.50	0.25-0.75	--	--	1.0	0.08-0.15
Malathion	0.5-2	--	1-2	0.25-1.0	0.25-0.5	--	--	--	0.5-1.0	--	--	--	0.5-1.0
Methyl parathion	0.25-0.75	--	0.25-0.5	--	0.25-0.5	--	--	--	--	--	0.25-0.5	--	0.25-0.50
Parathion	--	--	0.1-0.25	--	0.125-0.25	--	--	--	--	--	0.1-0.4	0.5	--
Sevin	1-2	1-2	--	0.5-1.0	0.5-1.0	--	--	--	--	2.0-2.5	--	--	0.5-1.0
Strobane	2-4	2-4	--	1.0	2-3	--	--	--	2-3	--	--	4.0	0.75-1.0
Toxaphene	2-4	2-4	--	1.0	2-3	2-5	2-3	1.0-2.5	2-3	--	--	4.0	0.75-1.0

1/ Not all species of spider mites are controlled with these materials. See table page 51 for principal miticides.
2/ Dust only.
3/ Does not control all species.
4/ Spray only.

COTTON INSECTS AND SPIDER MITES AND THEIR CONTROL

The insects and spider mites injurious to cotton and the recommended chemicals and procedures for their control are discussed in this section. For recommended dosages of the principal insecticides used for the control of the most important cotton pests see table on pages 36. In local areas certain insects have become resistant to one or more of the insecticides recommended for general use. See Resistance to Insecticides, page 14, for details.

Beet Armyworm (Laphygma exigua (Hbn.))

The beet armyworm is primarily a pest of seedling cotton, but it may also attack older plants. Squares and blooms may be destroyed, and feeding on the bracts may cause small bolls to shed. For light infestations on seedling cotton toxaphene-DDT as a spray or dust at 3 pounds of toxaphene plus 1.5 pounds of DDT per acre in ground equipment is effective. For severe infestations on older cotton, 0.5 pound of Dibrom plus 0.4 pound of endrin, 0.9 pound of Dilan plus 0.3 pound of endrin, and 1 pound of Dipterex will give control but 2 or 3 applications at weekly intervals may be necessary. (See Statement on Resistance, page 14).

Boll Weevil (Anthonomus grandis Boh.)

The boll weevil is the most important pest of cotton in the eastern half of the Cotton Belt. The effectiveness of insecticides approved for its control will vary not only in different localities but also with the season. The choice of insecticides will be determined by their effectiveness in the particular area where the insect is to be controlled. (See Statement on Resistance, page 13). Dosages of technical material that have controlled the boll weevil in one or more areas are as follows:

	Pounds per acre
Sprays or dusts:	
Aldrin	0.25-0.75
BHC (gamma isomer)	0.30-0.45
Calcium arsenate	7-15
Dieldrin	0.15-0.5
Endrin	0.2-0.5
Guthion	0.25-0.5
Heptachlor	0.25-0.75
Malathion	1-2
Methyl parathion	0.25-0.75
Sevin	1-2
Strobane	2-4
Strobane-DDT 2:1	2-3 plus 1.0-1.5
Toxaphene	2-4
Toxaphene-DDT (2:1)	2-3 plus 1.0-1.5

When these insecticides are used for boll weevil control, other insect problems have to be considered. Infestations of the cotton aphid, the bollworm, spider mites, and the tobacco budworm may develop when some of these insecticides are used alone. To avoid a rapid build-up of the bollworm and the tobacco budworm, DDT should always be added to aldrin, BHC, dieldrin, Guthion, heptachlor, malathion, and methyl parathion. (For rates see section under the respective insecticides or pests). Strobane and toxaphene, if properly timed, will control bollworms without DDT in some areas. However, if these materials are used alone late in the season, careful checks should be made at 3- to 5-day intervals, and if their numbers are found to be increasing, DDT should be included in subsequent applications or should be applied alone.

Aphids may build up rapidly after the use of calcium arsenate or DDT, or DDT formulated with aldrin, dieldrin, endrin, heptachlor, or toxaphene. Spider mites may build up rapidly after the use of the last five chemicals and BHC, either alone or with DDT. Careful checks should be made at 5- to 7-day intervals, and if these pests are found to be increasing control measures should be started at once. (See sections on cotton aphids and spider mites).

Insecticides should be applied for boll weevil control when definite need is indicated. Mid- and late-season applications should be made every 3 to 5 days as long as control is necessary. Fields should be inspected at least weekly until the crop is mature. Where early-season control is practiced, these applications are usually spaced a week apart during the period of abundance of overwintered weevils.

Bollworm (*Heliothis zea* (Boddie))
and Tobacco Budworm (*H. virescens* (F.))

The bollworm and the tobacco budworm are the common "bollworms" attacking cotton. Several other species of lepidopterous larvae that cause boll injury are discussed elsewhere in this report.

Effective control of bollworms depends on the thorough and timely use of properly formulated insecticides. Frequent field inspections to determine the presence of eggs and young larvae during the fruiting period are essential. For the most effective control it is essential that insecticide applications be made when larvae are small.

Bollworms are most effectively controlled with DDT, endrin, Sevin, a strobane plus DDT mixture, or a toxaphene plus DDT mixture, and in some areas are satisfactorily controlled with strobane and toxaphene.

Dosages of technical material that have controlled bollworms in one or more areas are as follows:

	Pounds per acre
Sprays or dusts:	
DDT	0.5-2.0
Endrin	0.2-0.5
Sevin	1-2
Strobane	2-4
Toxaphene	2-4
Toxaphene-DDT (2:1) ...	2-3 plus 1.0-1.5
Spray only:	
Strobane-DDT (2:1)	2-3 plus 1.0-1.5

In some areas where spider mites are a problem, organic insecticide dusts usually contain at least 40 percent of sulfur or an appropriate amount of some other suitable miticide.

Cabbage Looper (Trichoplusia ni (Hbn.))

The cabbage looper and related species are becoming more important as pests of cotton in many areas. They are difficult to control with insecticides. The following materials applied at 5-day intervals have given control in one or more areas (See statement on resistance, page 14):

	Pounds per acre
Sprays or dusts:	
Endrin	0.4-0.5
Endrin-methyl parathion mixture ...	0.5 plus 0.5
Spray only:	
Dipterex-DDT	1.5 plus 2
Strobane-DDT (2:1)	2-3 plus 1.0-1.5
Toxaphene-DDT (2:1) ...	2-3 plus 1.0-1.5

The cabbage looper is frequently controlled by a virus disease. When diseased loopers are commonly found, chemical control may be delayed or omitted.

Cotton Aphid (Aphis gossypii Glov.)

Heavy infestations of the cotton aphid may occur on cotton after the use of certain insecticides, and on seedling cotton and sometimes older cotton where no insecticides have been applied. The cowpea aphid is a pest on seedling cotton in some areas. (See statement on resistance, page 14).

Aphid build-up in the boll weevil areas can usually be prevented by any of the following treatments:

1. Endrin at 0.2 to 0.5 pound per acre in every application (where not formulated with DDT), in a dust or spray.

2. Guthion or methyl parathion at 0.25 to 0.5 pound or malathion at 1 to 2 pounds per acre in a dust or spray in every application or alternately with calcium arsenate.

3. Parathion 1 percent in low-lime calcium arsenate dust or added at the rate of 0.1 pound per acre to dusts or sprays of the following insecticides when formulated with DDT and used at the recommended rate for boll weevil control: Aldrin, BHC, dieldrin, heptachlor, strobane, and toxaphene.

4. Sevin at 1 to 2 pounds per acre in every application, applied as a dust.

5. Toxaphene or strobane at 2 to 3 pounds per acre in every application (where not formulated with DDT), in a dust or spray.

When aphid infestations are heavy and rapid kill is needed, any one of the following treatments is usually effective:

1. Demeton at 0.125 to 0.4 pound per acre, in a spray.

2. Diazinon at 0.25 pound per acre, in a spray.

3. Dipterex at 0.25 to 1 pound per acre, in a spray.

4. Malathion at 1 to 2 pounds per acre, in a dust or spray.

5. Methyl parathion at 0.25 to 0.5 pound per acre, in a dust or spray.

6. Parathion at 0.1 to 0.25 pound per acre, in a dust or spray.

7. Trithion at 0.25 to 1 pound per acre, in a dust or spray.

8. Ethion at 0.5 to 1 pound per acre, in a dust or spray.

Cotton Leaf Perforator (Bucculatrix thurberiella Busck)

The cotton leaf perforator is at times a serious defoliator of cotton in certain areas of southern California and Arizona. It is controlled with any of the following insecticides at the indicated dosages of technical material. (See statement on resistance, page 14):

Sprays or dusts:	Pounds per acre
Dilan	0.6-1.0
Dipterex	1
Malathion	1
Methyl parathion	0.5
Parathion	0.5
Sevin	1.75
Strobane	4
Toxaphene	4
Trithion	1

Repeat applications may be necessary. Sprays are more effective than dusts. Avoid use of organophosphorus compounds during early season to protect beneficial insects.

If bollworms are present, DDT at the rate of 0.5 to 1.5 pounds per acre should be added to each of these insecticides except Sevin.

Cotton Leafworm (Alabama argillacea (Hbn.))

The following insecticides will control the cotton leafworm at the indicated dosages of technical material (See statement on resistance, page 14):

Sprays or dusts:	Pounds per acre
Calcium arsenate	7-10
Dipterex	0.25-1.0
Endrin	0.2-0.5
Guthion	0.25-0.5
Malathion	0.25-0.5
Methyl parathion	0.25-0.5
Parathion	0.125-0.25
Sevin	0.5-1.0
Strobane	2-3
Toxaphene	2-3
Spray only:	
Delnav	0.25-0.5

Cutworms

Several species of cutworms, including the following, may develop in weeds or crops, especially legumes, and then attack adjacent cotton or cotton planted on land previously in weeds or legumes:

Black cutworm (Agrotis ypsilon (Rott.))
Pale-sided cutworm (Agrotis malefida Guen.)
Variegated cutworm (Peridroma margaritosa (Haw.))
Granulate cutworm (Feltia subterranea (F.))
Army cutworm (Chorizagrotis auxiliaris (Grote))

Recommended control measures include thorough seed-bed preparation, elimination of weed host plants, and the use of insecticides. In western areas irrigation forces the subterranean forms to the surface, where they may be treated with insecticides or destroyed by natural factors. If an infested area is plowed under 3 to 6 weeks before the cotton crop is seeded, it may not be necessary to use an insecticide.

The following insecticides will control one or more species of cutworms at the indicated dosages of technical material:

	Pounds per acre
Sprays or dusts:	
DDT	1.0-2.5
Dieldrin	0.3-0.5
Endrin	0.2-0.5
Toxaphene	2-5
Spray only:	
Toxaphene-DDT (2:1) ...	2-3 plus 1.0-1.5

Poison baits containing DDT, dieldrin, endrin, or toxaphene have been satisfactory. Baits are frequently more effective than sprays or dusts against some species of cutworms.

Darkling Ground Beetles (Blapstinus and Ulus spp.)

Darkling ground beetles, the adults of false wireworms, occasionally affect the stand of young cotton in the western areas. Adults on young plants may be controlled with DDT, toxaphene, or toxaphene-DDT mixture (2:1) at 1 to 2 pounds, aldrin at 0.5 pound, dieldrin at 0.25 to 0.375 pound, and heptachlor at 0.5 pound per acre applied in sprays. The larvae may be controlled by slurrying 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane with a suitable fungicide onto each 100 pounds of planting seed.

Fall Armyworm (Laphygma frugiperda (J. E. Smith))

The fall armyworm occasionally occurs in sufficient numbers to damage cotton. The following insecticides will control them at the indicated dosages of technical material:

	Pounds per acre
Sprays or dusts:	
BHC-DDT	0.3 + 0.5 - 0.45 + 0.75
DDT	1-1.5
Endrin	0.2-0.3
Toxaphene	2-3

The results obtained from these materials have varied in different states; therefore, local recommendations should be followed. (Also see Bollworm, page 38).

Field Cricket (Acheta sp.)

The field cricket occasionally feeds on cotton bolls and seedling plants in the Imperial Valley of California and in Arizona. During periods of drought late in the season they may feed on the seed of open bolls, especially in the Delta sections of Arkansas, Louisiana, and Mississippi. This feeding is usually done at night as the crickets hide during the day in deep cracks in the soil. Crickets may be controlled by foliage applications of a 10-percent DDT or 2.5-percent aldrin, dieldrin, or heptachlor dust at 20 to 30 pounds per acre. A BHC dust containing 2 percent gamma plus 5 percent of DDT plus 40 percent of sulfur applied at 15 to 20 pounds per acre is also effective.

Fleahoppers

Cotton Fleahopper (Psallus seriatus (Reut.)) and
Black Fleahopper Complex (Spanogonicus albofasciatus (Reut.) and Rhinacloa forticornis (Reut.))

The cotton fleahopper frequently attacks cotton in Texas, Oklahoma, and to a lesser extent eastward during the early fruiting period of cotton. The black fleahopper complex similarly occurs in the irrigated West. (See statement on resistance, page 14). These insects can be controlled with the following insecticides at the indicated dosages of technical material:

Cotton Fleahopper

Sprays or dusts:	Pounds per acre
Aldrin	0.25
BHC (gamma)	0.1
DDT	0.5
Dieldrin	0.15
Endrin	0.1
Guthion	0.25
Heptachlor	0.25
Malathion	0.25-1.0
Sevin	0.5-1.0
Strobane	1.0
Toxaphene	1.0

Black Fleahopper Complex

Sprays or dusts:	Pounds per acre
Dibrom	1.0
Dieldrin	0.375
Dipterex	1.0
Endrin	0.4
Heptachlor	0.5
Malathion	0.25-1.0
Strobane	1.0-3.0
Toxaphene	1.0-3.0
Trithion	1.0

Garden Webworm (Loxostege similalis (Guen.))

The garden webworm may be controlled on cotton with the following insecticides applied as dusts or sprays at the per-acre dosage indicated: BHC-DDT to give 0.45 pound of gamma and 0.75 pound of DDT, DDT at 1 pound, dieldrin at 0.3 pound, endrin at 0.3 pound, Guthion at 0.5 pound, heptachlor at 0.4 pound, parathion at 0.15 pound, strobane or toxaphene at 3 pounds, and strobane-DDT (2:1) or toxaphene-DDT (2:1) at 3 pounds. DDT has given better control in sprays than in dusts, but is generally less effective than the other materials. Control measures should be applied as soon as possible after the worms appear.

Grasshoppers

Several species of grasshoppers, including the following, sometimes attack cotton:

American grasshopper (Schistocerca americana (Drury))
Desert grasshopper (Trimeritropis pallidipennis (Burm.))
Differential grasshopper (Melanoplus differentialis (Thos.))
Lubber grasshopper (Brachystola magna (Gir.))
Migratory grasshopper (Melanoplus bilituratus Walker) formerly M. mexicanus (Sauss.))
Red-legged grasshopper (M. femur-rubrum (DeG.))
Two-striped grasshopper (M. bivittatus (Say))

The American grasshopper overwinters as an adult, and in the spring deposits eggs in the fields, but the other species overwinter as eggs in untilled soil, fence rows, sod waterways, around stumps, and similar locations. The species overwintering in the egg stage can best be controlled with early treatment of hatching beds before the grasshoppers migrate into the fields. Sprays or dusts containing aldrin, BHC, dieldrin, endrin, heptachlor, or toxaphene have largely replaced poison baits, particulraly where grasshoppers must be controlled on lush or dense vegetation.

BHC sprays and dusts usually kill the grasshoppers in a few hours, but results have been erratic and residual effectiveness is limited to 1 to 2 days. Aldrin, dieldrin, endrin, and toxaphene are very effective but slower in their action; however, they remain effective up to several weeks.

Dosages of technical material suggested to control grasshoppers come within the following ranges:

	Pounds per acre
Aldrin	0.1-0.25
BHC,(gamma).....	0.3-0.45
Dieldrin	0.07-0.125
Endrin	0.2-0.5
Heptachlor	0.25-0.5
Toxaphene	1-2.5

The lowest dosages are effective against newly hatched to half-grown grasshoppers. The dosage should be increased as the grasshoppers mature or when the material is applied on partly defoliated plants or on plants unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control, particularly in sparse vegetation.

Lygus Bugs and Other Mirids

Several species of lygus bugs and other mirids, including the following, are often serious pests of cotton (see statement on resistance, page 14):

Ragweed plant bug (*Chlamydatus associatus* (Uhl.))
Rapid plant bug (*Adelphocoris rapidus* (Say))
Superb plant bug (*A. superbus* (Uhl.))
Tarnished plant bug (*Lygus lineolaris* (P. de B.))
Other lygus bugs (*L. hesperus* Knight and *elisus* Van D.)
Other mirids (*Creontiades debilis* (Van D.), *C. femoralis* (Van D.), and *Neurocolpus nubilus* (Say)) (See section on Fleahoppers)

These insects cause damage to squares, blooms, and small bolls of cotton and constitute a major problem, particularly in the vicinity of alfalfa fields in the irrigated areas of the West.

The following insecticides will control lygus bugs and other mirids at the indicated dosages of technical material:

	Pounds per acre
Sprays or dusts:	
Aldrin	0.25-0.75
BHC (gamma)	0.3-0.45
DDT	1.0-1.5
Dieldrin	0.15-0.5
Dilan	1.0
Dipterex	1.0-1.5
Endrin	0.2-0.5
Ethion	1-1.5
Heptachlor	0.25-0.75
Malathion	0.5-1.0
Strobane	2-3
Toxaphene	2-3

Pink Bollworm (Pectinophora gossypiella (Saund.))

The most intensive inspection ever conducted for pink bollworm failed to reveal any spread of the pest in the 1959 crop season. Of the nine Arkansas counties outside the area under regulation in 1957 in which pink bollworms were reported for the first time in 1958, only one worm was found in a single county (Pulaski) in 1959. Of the 18 parishes in Louisiana in which pink bollworm was reported in 1958, only 9 were found to be infested in 1959. An unusual situation developed in that the 1959 infestation in Louisiana shifted into the northern part of the State.

The pink bollworm eradication program inaugurated in central Arizona in 1958 was conducted vigorously in 1959 with satisfactory progress toward eventual eradication. Approximately 75,000 acres of known infested fields and exposed acreage were treated an average of eight times at six-day intervals, beginning when squares were available for oviposition by the pink bollworm. Most of the infestations found in central Arizona in the fall of 1959 were located outside of the treated area. Of the 3,785 acres found infested in the late summer and fall, 1593 acres were found early enough to receive several applications of insecticide. Including security acreage to be treated, the acreage requiring treatment in 1960 should not exceed 20% of that treated in 1959. Intensive inspections for pink bollworm in western Mexico, in Baja California, Mexico, and in the State of California and in Yuma County, Arizona were negative again in 1959. Cooperation of the Republic of Mexico continues to be of immeasurable value to the efforts in keeping these areas free of pink bollworm.

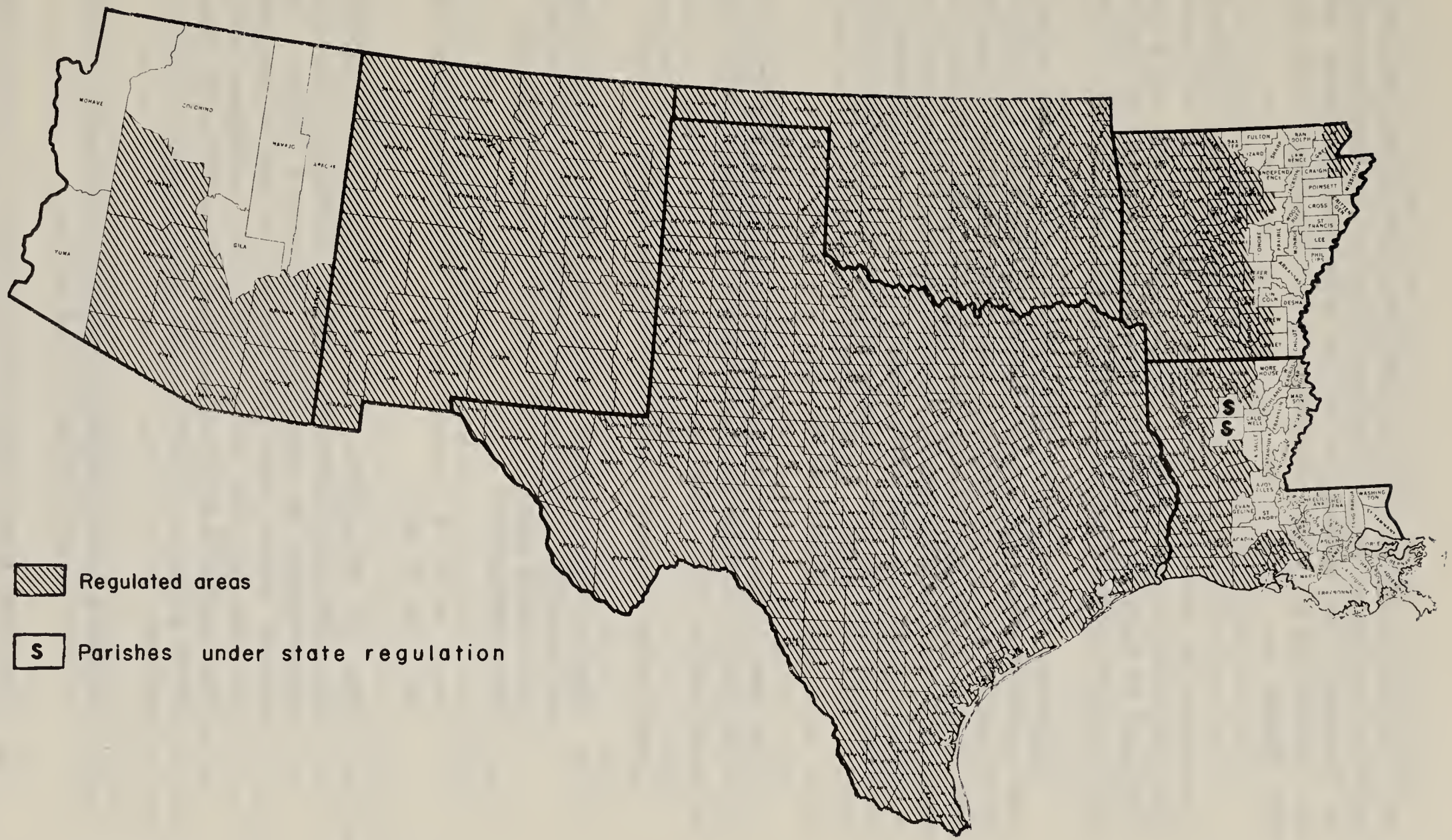
One disturbing factor with a possible detrimental influence on the pink bollworm situation in Arizona and prevention of its entry into California lies in the tremendous increase of infestation in a small area of the Juarez Valley of Mexico, El Paso County, Texas, and Dona Ana County, New Mexico. There were several thousands acres of heavily infested cotton with portions of several fields aggregating well over a hundred acres where a potential crop of over two bales per acre was totally destroyed by the pink bollworm. One encouraging situation with respect to eastward spread of pink bollworm is the fact that infestation in eastern Oklahoma, east and northeast Texas, was lower in 1959 than in 1958.

See map on page 47 for regulated area in the United States as of January 1, 1960.

Quarantine requirements.--Regulated area under Pink Bollworm Quarantine No. 52 was revised June 9, 1959, to add the Arizona counties of Maricopa, Pinal, Yavapai, and that part of Pima County not previously regulated; a north-south strip of territory through the center of Arkansas and portions of 4 counties in the northeastern corner of the State; and

PINK BOLLWORM REGULATED AREAS

JANUARY 1, 1960



U.S. DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

the Parishes of Grant, Lincoln, Rapides, and Union, and part of Ouachita, in Louisiana. See Administrative Instructions, PPC 621, 2nd Revision, for description of the counties, parishes, or portions of counties and parishes involved or the map which forms a part of this report.

The regulations, in general, require that all infested cotton or articles be treated to free them of living pink bollworms before they are moved to free areas. Copies of the State and Federal regulations may be obtained from the regulatory agencies of the affected states or from the Plant Pest Control Division field offices.

Cultural control.--The pink bollworm, unlike any other cotton insect, hibernates only in the fields in which it is produced unless taken away in the harvesting of the crop. Approved cultural practices greatly reduce the overwintering population and are the most effective means of combating this pest. Mandatory cultural-control zones are in effect in all the regulated areas of Arizona, Arkansas, and Louisiana, in all of south Texas, and in the southern portions of central and east Texas. There are also mandatory cultural-control zones in Mexico adjacent to Texas.

The same cultural practices followed in the control of the pink bollworm greatly reduce the boll weevil carryover if the plants are destroyed while still green.

Recommended control practices include the following:

1. Shorten the planting period and plant at the optimum time for a given locality. Use seeds of an early-maturing variety, which have been culled, treated with a fungicide, and tested for germination.

2. Leave as thick a stand as has been recommended for a section and type of soil.

3. See that the cotton crop is produced in the shortest practicable time. Early-season control of certain insects has proved advantageous in some States but not in others. Practice early-season control where recommended by controlling aphids, the boll weevil, the cotton fleahopper, cutworms, thrips, and any other insects which may retard the growth and fruiting of young plants. Protection of early fruit will assure an early harvest.

4. Withhold late irrigation and use defoliants or desiccants to hasten the opening of the bolls.

5. Shred and plow under cotton stalks as soon as possible after harvest. Okra stalks should be shredded and plowed under at the same time because this plant is a preferred secondary host.

6. In cold arid areas where winter irrigation is not feasible, leave stalks standing until lowest temperatures have occurred in order to secure a maximum kill of pink bollworms in the bolls on the stalks. However, if a large amount of crop debris such as seed cotton or locks is on the soil surface, a high survival of the pest may result so the stalks should be shredded and plowed under as early and as deeply as possible.

The flail type stalk shredder is recommended over the horizontal rotary type for pink bollworm control. The flail shredder will kill about 85 percent of the pink bollworms left in the field after harvest, compared with 55 percent for the horizontal rotary type. The residue should be plowed under as deeply as possible. Pink bollworm winter survival is highest in bolls on the soil surface and is six times as high in bolls buried only 2 inches as compared with bolls buried 6 inches deep. All sprout and seedling cotton and okra developing after plowing should be destroyed before fruiting to create a host-free period between crops. In arid areas, if the crop debris is plowed under in the late fall or early winter, the fields should be winter-irrigated to increase pink bollworm mortality.

Control with insecticides.--Where infestations are heavy, crop losses from the pink bollworm can be reduced by proper use of insecticides. Weekly applications of 2 to 3 pounds of DDT, 0.25 to 0.5 pound of Guthion plus 1.5 to 1 pound of DDT, or 2 to 2.5 pounds of Sevin will control the pink bollworm. Guthion at 0.25 to 0.5 pound plus DDT at 1 to 0.5 pound or Sevin at 1.5 to 2 pounds per acre when applied at 4- to 5-day intervals will control the boll weevil, bollworm, and pink bollworm. DDT can also be mixed with the other organic insecticides used for the control of cotton pests, and when the interval of application is 4 to 5 days the mixture should contain enough DDT to give 1 to 1.5 pounds per acre. The use of these insecticides for control of other cotton insects exerts a repressive effect on pink bollworm populations.

Eradication measures.--Eradication of the pink bollworm is possible in any given area not subject to constant reinfestation. Early programs of eradication were dependent primarily on non-production of cotton in the affected area plus a security zone around the known infestation. The last infestation eradicated in Arizona in 1947 and practices currently in use in the eradication of the pink bollworm in central Arizona include a combination of such practices as (1) stalk destruction and field clean-up, (2) deep plowing under of crop residues, (3) elimination of volunteer plants, (4) prohibition of production of stub cotton, and (5) an insecticide program involving a minimum of eight applications of DDT early in the season. Gin sanitation and heat treatment of cottonseed were an important phase of the over-all program.

The essentials of an eradication program have improved in the interim since that program was inaugurated in 1947. Recently improved

stalk shredders which kill up to 85 percent of the pink bollworms in bolls passing through them are more effective than the early developed rotary shredders and can be utilized to replace expensive hand cleaning formerly required. Also, better defoliants are available which can be applied to hasten maturity of the late bolls, which will in turn hasten harvest, stalk shredding, and plow-under of crop residues. The importance of a short, uniform planting period at the optimum time is recognized as a distinct aid in the further reduction of initial infestations from overwintering larvae.

Salt-Marsh Caterpillar and Other Arctiids

The salt-marsh caterpillar (Estigmene acrea (Drury)) is a late-season pest of cotton in western irrigated areas. It may be controlled with 2 pounds of Sevin in a dust, 0.7 pound of Dilan, 2 pounds of Dipterex, 0.5 to 1 pound of parathion, 1 pound of trithion, or a mixture of 0.5 pound of methyl parathion plus 0.4 pound of endrin applied as sprays. (See statement on resistance, page 14). Bacillus thuringiensis was effective in field tests in Arizona in 1959.

Occasionally the yellow woollybear (Diacrisia virginica (F.)) and the hairy larvae of several other tiger moths (Arctiidae), including Callarctia phyllira (Drury), C. arge (Drury), and C. oithona Strk., cause serious damage to cotton. Information is needed in regard to their seasonal host plants, distribution, natural enemies, causes of serious outbreaks in cotton fields, life history, and control. Determinations by specialists should always be obtained.

Seed-Corn Maggot (Hylemya cilicrura (Rond.))

The seed-corn maggot may seriously affect the stand of cotton, particularly when planting closely follows the turning under of a green manure crop or other heavy growth. This insect may be controlled with 1 to 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane in a wettable powder mixed with a suitable fungicide and applied onto each 100 pounds of planting seed. Seed should be treated immediately before planting.

Spider Mites

The following spider mites are known to attack cotton:

Brown wheat mite (Petrobia latens (Muell.))
Carmine spider mite (Tetranychus cinnabarinus (Boisduval))
Desert spider mite (T. desertorum Banks)
Four-spotted spider mite (T. canadensis McG.)
Lobed spider mite (T. lobosus Boudreaux)
Pacific spider mite (T. pacificus McG.)
Schoene spider mite (T. schoenei McG.)
Strawberry (Atlantic) spider mite (T. atlanticus McG.)

Tumid spider mite (T. tumidus Banks)
Two-spotted spider mite (T. telarius (L.))
Also T. gloveri Banks and T. ludeni Zacher

These species differ in their effect on the cotton plant and in their reaction to miticides. Accurate identification of the species is essential. The use of organic insecticides for cotton-insect control has been a factor in increasing the importance of spider mites as pests of cotton.

The following table lists the species of spider mites and the miticides which have been found to be effective in their control (see statement on resistance, page 14):

	Species of Mite							
Miticide	Brown Wheat	Carmine	Desert	lobed	Pacific	Strawberry (Atlantic)	Tumid	Two-spotted
Aramite		0.75-1	0.3-0.75		1	1	0.3-0.75	0.75-1
Demeton		0.25-0.4	0.25-0.4		0.25-0.4	0.25-0.4	0.25-0.4	0.25-0.4
Ethion		0.5-1	0.5-1	0.5		0.5-1	0.5-1	0.5-1
Guthion			0.25-0.5				0.25-0.5	
Kelthane			1		1	1	1	1
Methyl parathion			0.25-0.5				0.25-0.5	
Parathion	0.3	0.2-0.4	0.1-0.25				0.1-0.25	0.2-0.4
Sulfur	25-30		20-25			20-25	20-25	
Tedion		1			0.5-0.75			0.5-0.75
Trithion		0.25-1	0.5-1	0.5	0.75-1.0	0.5-1	0.5-1	0.25-1

In some areas mites may be controlled by including a suitable miticide at a comparatively low rate in all insecticide applications. For control of some species and suppression of others at least 40 percent of sulfur may be incorporated in dusts. Elemental sulfur cannot be incorporated in sprays applied at low gallonage, but other miticides may be substituted. Sulfur dust is most effective when finely ground and when applied at temperatures above 90° F. Thorough coverage is essential.

Stink Bugs

The following stink bugs are sometimes serious pests of cotton:

Brown cotton bug (Euschistus impictiventris Stal)
Brown stink bug (E. servus (Say))
(also E. variolarius (P. de B.), E. tristigmus (Say), and E. conspersus Uhl.)
Conchuela (Chlorochroa ligata (Say))
Green stink bug (Acrosternum hilare (Say))
Red-shouldered plant bug (Thyanta custator (Fab.))
(also T. rugulosa (Say), T. brevis Van D., and T. punctiventris Van D.)
Say stink bug (Chlorochroa sayi Stal)
Southern green stink bug (Nezara viridula (L.))

The importance of these pests and the species involved vary from year to year and from area to area. The damage is confined principally to the bolls and results in reduced yields and lower quality of both lint and seed.

The following insecticides applied at the indicated dosages of technical material have given control of stink bugs:

	Pounds per acre
Sprays or dusts:	
BHC (gamma)	0.5
Dieldrin	0.45
Dipterex	1.5
Heptachlor	1.0
Parathion	0.5
Strobane	4.0
Toxaphene	4.0

Thrips

Thrips often injure cotton seedlings, especially in areas where vegetables, legumes, and small grains are grown extensively. The following species have been reported as causing this injury (see statement on resistance, page 14):

Flower thrips (Frankliniella tritici (Fitch))
(also F. runneri (Morg.), F. exigua Hood, F. occidentalis (Perg.), and F. gossypiana Hood)
Onion thrips (Thrips tabaci Lind.)
Sericothrips variabilis (Beach)
Tobacco thrips (F. fusca (Hinds))

In some areas cotton plants usually recover from thrips injury to seedlings; therefore, control is not recommended unless the stand is threatened. In other areas thrips damage is more severe and control measures are generally recommended. Injury by thrips alone, or the combined injury of thrips and disease, may reduce or even destroy stands of young plants. A heavy infestation may retard plant growth and delay fruiting and crop maturity. Although thrips are predominantly pests of seedlings, damaging infestations sometimes occur on older cotton in certain areas.

The following insecticides at the indicated dosages of technical material are recommended when the situation warrants their use:

	Pounds per acre
Sprays or dusts:	
Aldrin	0.08-0.15
BHC (gamma)	0.1-0.2
DDT	0.25-1.50
Dieldrin	0.08-0.15
Endrin	0.08-0.15
Guthion	0.25-0.50
Heptachlor	0.08-0.15
Malathion	0.5-1.0
Methyl parathion	0.25-0.50
Sevin	0.5-1.0
Strobane	0.75-1.0
Toxaphene	0.75-1.0

When applications are made by airplane, the above dosages should be increased by at least 50 percent.

Methyl parathion and parathion are effective against thrips but are not generally recommended because their residual toxicity is shorter than that of insecticides commonly used for thrips control.

The bean thrips (Hercothrips fasciatus (Perg.)) is an occasional mid-season pest of cotton in parts of California. DDT at 1 pound or toxaphene at 2 to 3 pounds per acre gives satisfactory control when applied in either a spray or dust.

Scirtothrips sp. causes severe crinkling of top leaves of cotton in localized areas of Arizona, Mississippi, and Texas.

Kurtomalthrips morrilli Moulton was described in 1927 from specimens taken on cotton at Gila Bend, Arizona. It was collected from cotton at Seeley, California, on May 2, 1930, at Laveen, Arizona, on July 23, 1943, and was reported as causing severe injury to cotton at Gila Bend, Arizona, in July 1957.

White-fringed Beetles (Graphognathus spp.)

White-fringed beetles are pests of cotton and many other farm crops in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. The larvae feed on the roots of young plants. These insects can be controlled by good cultural practices and with insecticides. Recommended cultural practices include the following:

1. In heavily infested areas plant oats or other small grains.

2. Restrict planting of summer legumes, such as peanuts, soybeans, velvetbeans, or other favorable host plants of the adult beetles, to not more than one-fourth of the total crop land. Do not plant these crops on the same land more often than once in 3 or 4 years.

3. Do not intercrop corn with peanuts, soybeans, crotalaria, or velvetbeans. Prevent the growth of broadleaved weeds such as cocklebur and sicklepod.

4. Improve poor soils by turning under winter cover crops.

The following insecticides when applied at the given dosages are effective against white-fringed beetle larvae. Broadcast the insecticide when preparing the soil for planting and immediately work into the upper 3 inches, or apply it alone or mixed with fertilizer, in row at time of planting. The insecticide may be used in a spray, dust, or granules.

	Pounds per acre	
	Broadcast	In drill row
Aldrin	2	0.75-1.0
Chlordane	5	1-2
DDT	10	2-3
Dieldrin	1.5	0.5-0.75
Heptachlor	2	0.75-1.0

Broadcast applications remain effective as follows: Aldrin, chlordane, or heptachlor for 3 years, DDT for 4 years, and dieldrin for 4 or more years. Drill-row applications must be renewed each year.

When applied to the foliage as recommended for the control of other cotton insects, a BHC-DDT mixture, toxaphene, or any one of the insecticides named above will give a residue in the soil which aids in the control of white-fringed beetles.

Wireworms

Several species of wireworms are associated with cotton. Damage is caused by the sand wireworm (Horistonotus uhlerii Horn) in South Carolina, Louisiana, and Arkansas and by the Pacific Coast wireworm (Limonius canus Lec.) in California. Adults of the tobacco wireworm or spotted click beetle (Conoderus vespertinus (F.)) are frequently found on the cotton plant, but the amount of damage the larvae cause to cotton is insignificant. Wireworms together with false wireworms and the seed-corn maggot sometimes prevent the establishment of a stand. To control these insects treat the seed with 1 to 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane plus a suitable fungicide per 100 pounds in a slurry.

Approved crop-rotation practices, increased soil fertility, and added humus help to reduce damage to cotton by the sand wireworm. Aldrin, BHC, dieldrin, endrin, heptachlor, and lindane as soil treatments are also effective against wireworms.

Yellow-striped Armyworm (Prodenia ornithogalli Guen.)
and Western Yellow-striped Armyworm (P. praefica Grote)

These insects sometimes cause considerable damage to cotton. The yellow-striped armyworm is difficult to kill with insecticides. However, DDT at 1 pound, dieldrin at 0.3 pound, or toxaphene at 2.5 pounds per acre in an emulsion spray gives fair control when used in the early stages of worm development. Dieldrin in a 3-percent dust and toxaphene in a 20-percent dust applied at 15 pounds per acre also give good kills of both large and small larvae.

The western yellow-striped armyworm, which attacks cotton in California, is controlled with DDT at 1 to 1.5 pounds Dipterex at 0.5 pounds or toxaphene at 2 to 3 pounds per acre applied in a dust or spray. Migrations from surrounding crops may be stopped with barriers of 10-percent DDT or 20-percent toxaphene at 2 to 4 pounds per 100 linear feet.

Miscellaneous Insects

Several Anomis leafworms are known to occur in the cotton-growing regions of Africa, Asia, North, Central, and South America, and the East and West Indies. Three species--erosa Hbn., flava fimbriago Steph., and texana Riley--occasionally damage cotton in the United States. They are often mistaken for the cotton leafworm, and are sometimes found on the same plants with it. Although specific control data are lacking, the insecticides recommended for control of the cotton leafworm might also be effective against Anomis leafworms.

The barber pole caterpillar, a pyraustid larva, Noctuelia rufofascialis, is reported occasionally attacking cotton bolls in Imperial and San Joaquin Valley areas of California. It also has been reported from Texas and Oklahoma.

The brown cotton leafworm (Acontia dacia Druce) was collected from three counties in Texas in 1953. Since then damaging infestations have occurred over wide areas of Texas and in Louisiana, and recoveries have been reported from Arkansas. This pest may be controlled with endrin at 0.33 pound, Guthion at 0.25 pound, malathion at 0.25 pound, and parathion at 0.125 pound per acre.

Leaf beetles of the genus Colaspis are widespread and often found on cotton, frequently on the foliage near the base of squares and bolls, where they usually feed on the bracts surrounding them.

The corn silk beetle (Luperodes brunneus (Crotch)) has been reported as a pest of cotton in localized areas in South Carolina, Georgia, Alabama, Mississippi, and Louisiana, but little is known about it.

The cotton square borer (Strymon melinus (Hbn.)) occurs throughout the Cotton Belt, but rarely causes economic damage. The injury it causes to squares is often attributed to the bollworm.

The cotton stainer (Dysdercus suturellus (H.-S.)) is found within the United States in Florida only. However, probably owing to mistaken identity, the literature also records it from Alabama, Georgia, and South Carolina. No work on control has been formally reported in recent years, but observations indicate that dusts containing BHC 1 percent gamma or 10 percent of toxaphene will control insects of this genus. DDT may also be effective.

The cotton stem moth (Platyedra vilella (Zell.)), a close relative of the pink bollworm, was first discovered in the United States in 1951, when larvae were found feeding in hollyhock seed at Mineola, Long Island, N. Y. It is recorded as a pest of cotton in Iran, Iraq, Morocco, Transcaucasia, Turkestan, and U.S.S.R., and as feeding on hollyhock and other malvaceous plants in England, France, and central and southern Europe. Collections made in 1953 extended its known distribution in this country to a large part of Long Island and limited areas in Connecticut and Massachusetts. Extensive scouting during 1954 disclosed that it had reached 11 counties in 4 States, as follows: Connecticut: Hartford and New Haven; Massachusetts: Essex and Plymouth; New Jersey: Monmouth, Ocean, and Union; New York: Westchester and all counties of Long Island (Nassau, Queens, and Suffolk). There has been no reported spread since 1954. Although

this species has not been found in the Cotton Belt in the United States, it is desirable to keep on the lookout for it on cotton, hollyhock, and other malvaceous plants. In 1956 it was collected from a natural infestation on cotton growing on the laboratory grounds at Farmingdale, N. Y.

The cowpea aphid (Aphis medicaginis Koch) (See page 39), the green peach aphid (Myzus persicae (Sulz.)), and the potato aphid (Macrosiphum solanifolii (Ashm.)) are common on seedling cotton. Cotton is not believed to be a true host of these species.

The cowpea curculio (Chalcodermus aeneus Boh.) sometimes causes damage to seedling cotton.

The European corn borer (Pyrausta nubilalis (Hbn.)) was first reported on cotton in the United States during 1955. The first report came from Franklin County, Tenn., where a few plants near the edge of a field were severely damaged. This was on July 3 in a 3-acre field adjacent to one that was in corn the previous year. The cotton was only 8 to 10 inches high at that time, and the larvae had entered the stems 2 to 6 inches from the ground and burrowed up through their centers. In August light infestations were reported in cotton in Dunklin, New Madrid, Pemiscot, Butler, Stoddard, and Mississippi Counties in Missouri, and in Madison County, Tenn. The borers were found boring into the upper third of the stems, and second- and third-instar larvae were attacking small bolls. These records are of special interest in view of the fact that the European corn borer is apparently spreading in the Cotton Belt. No reports of this insect on cotton were received during 1956 or 1957. In 1958 it was found boring in cotton stalks in Autauga and Madison Counties, Alabama, and in Washington County, Mississippi, in late July. In 1959 as many as 10 percent of the plants were infested in a 10-acre field of cotton in Etowah County, Alabama. The field was planted to corn in 1958. Damage was confined to the terminal 6 to 8 inches of the plant. Other infestations were noted in cotton fields in Autauga County, Alabama. In other parts of the world, particularly in Russia, Turkestan, and Hungary, it has been reported as a serious pest of cotton. One reference states "In Turkestan it is principally cotton which is attacked by the larvae and in which they bore long tunnels in the upper part of the stems." Entomologists and other interested persons throughout the Cotton Belt should be on the alert to detect its presence on cotton and, whenever possible, record the type and degree of injury, seasonal and geographical distribution, and control measures that might be of value.

False chinch bugs.--Bugs of the genus Nysius (N. erica (Schilling), N. californicus Stal and N. raphanus Howard), commonly called false chinch bugs, frequently migrate to cotton from adjacent weed hosts. Stands of seedling cotton may be destroyed by adults and nymphs. Aldrin, dieldrin, endrin, and heptachlor are effective at 0.4 to 0.6 pound per acre.

Flea beetles.--The pale-striped flea beetle (Systena blanda Melsh), the elongate flea beetle (S. elongata (F.)), and S. frontalis (F.) sometimes cause serious damage to seedling cotton in some areas. They can be controlled with aldrin at 0.25 to 0.5 pound, DDT at 1 pound, dieldrin at 0.25 to 0.33 pound, or toxaphene at 2 to 3 pounds per acre in dusts or sprays. The sweetpotato flea beetle (Chaetocnema confinis Crotch) was found injuring seedling cotton in the Piedmont section of South Carolina in May 1954. The striped flea beetle Phyllotreta striolata caused damage to cotton in Alabama in 1959. Other species of flea beetles have been reported from cotton, but records regarding the injury they cause are lacking. When flea beetle injury to cotton is observed, specimens should be submitted to specialists for identification, with a statement regarding the damage they cause, the locality, and the date of collection.

The garden springtail (Bourletiella hortensis (Fitch)) injured cotton locally in Hertford County, North Carolina, in early May 1958. Another springtail (Entombrya unostrigata Stach.) damaged seedling cotton over a wide area of the southern high plains of Texas and New Mexico during 1955 through 1957.

The greenhouse leaf tier (Udea rubigalis (Guen.)), also known as the celery leaf tier, became extremely abundant on cotton in the San Joaquin Valley in 1954. Despite the heavy populations, damage was generally slight and restricted to foliage on the lower third of the plants in lush stands. In the few places where it was necessary to control this pest, a dust containing 5 percent of DDT plus 10 to 15 percent of toxaphene at 25 to 35 pounds or endrin at 0.4 pound per acre in a dust or spray was effective.

The harlequin bug, Murgantia histrionica (Hahn), heavily infested a few cotton fields in Graham County, Arizona, in August of 1959. Feeding was similar to that of other stink bugs. No immature stages were noted.

Several leafhoppers of the genus Empoasca are often abundant on cotton in many sections of the Cotton Belt. Only in California, however, has serious injury been reported, and this was caused by two species, solana DeL. (southern garden leafhopper) and fabae (Harris). These species are known to be phloem feeders on some crops and cause damage typical of this type of feeding on cotton. In the San Joaquin Valley, where fabae occurs, satisfactory control has been obtained with 1 to 1.5 pounds of DDT per acre. In the desert areas, where solana occurs, malathion at 0.75, parathion at 0.25 to 0.5, or Sevin at 1 to 2 pounds per acre has given satisfactory results.

Several of the leaf rollers (Tortricidae) occasionally damage cotton. Platynota stultana (Wlsm.) and rostrana (Wlk.) are the species most commonly recorded, but flavedana Clem., idaeusalis (Wlk.) and nigrocervina (Wlsm.) have also been reported. These species are widely distributed and have many host plants. P. stultana has at times been a serious pest of cotton in the Imperial Valley of California and parts of Arizona and New Mexico. DDT at 2 to 3 pounds or parathion at 1 pound per acre were the most promising materials tested. Dipterex at 1 to 1.5 pound per acre will control P. stultana.

The pink scavenger caterpillar (Pyroderces rileyi (Wlsm.)) is one of several insects that resemble the pink bollworm, and is sometimes mistaken for it by laymen. The larva is primarily a scavenger in cotton bolls and corn husks that have been injured by other causes.

Adults of the buprestid beetle Psiloptera drummondi L. & S. occasionally cause damage to cotton. The damage consists of partially girdled terminals which break over and die. Control measures were directed against this insect on a 10-acre cotton field at Dona Ana, New Mexico, in August 1954, where 80 to 90 percent of the terminals had been clipped. A 5-percent DDT dust applied by air at 30 pounds per acre gave good control.

Root aphids known to attack cotton are the corn root aphid (Anuraphis maidi-radicis (Forbes)), Trifidaphis phaseoli (Pass.), and Rhopalosiphum subterraneum Mason. So far as is known, injury prior to 1956 was confined to the Eastern Seaboard. Trifidaphis phaseoli (detd. by L. M. Russell) destroyed spots of cotton up to 1½ acres in fields in Pemiscot County, Missouri, in 1956. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant (Lasius alienus americanus Emery). Chemical control of root aphids has been directed at this ant. Some of the new materials are known to be effective as soil insecticides, and it is suggested that they be tested against root aphids attacking cotton. Root aphids injure cotton chiefly in the seedling stage. Since cotton in this stage often shows injury without any evidence of insects being present, the underground portions should be examined carefully. Ant mounds at the base of these plants indicate the presence of root aphids.

The serpentine leaf miner (Liriomyza propepusilla Frost) has been present in large numbers in some areas during the last few years. Drought conditions favor infestations of this pest. Heavy infestations may result in considerable leaf shed. Infestations are brought under control by rain or irrigation. Field tests at Waco, Texas, showed that the best reductions were obtained with parathion at 0.25 pound per acre.

Snowy tree cricket (Oecanthus niveus (DeG.)) infestations caused alarm to some southwestern Oklahoma cotton growers in Mid-July 1958. Approximately 3 percent lodging occurred in the Blair area.

The stalk borer (Papaipema nebris (Guen.)) is widely distributed east of the Rocky Mountains. It attacks many kinds of plants, including cotton, and is so destructive that one borer in a field may attract attention. The borers are most likely to be noted near the edges of cotton fields. Light marginal injury occurred in scattered fields in Missouri during June 1957, and it was also reported as causing some injury to cotton in Mississippi and Tennessee in 1956. It is sometimes mistaken for the European corn borer. Clean cultivation and keeping down weed growth help to hold them in check. The use of stalk shredders early in the fall should reduce their numbers. Information is needed concerning the effectiveness of chemicals for the control of this insect.

Striped blister beetles, Epicauta vittata (F.), sometimes cause severe foliage damage in small localized areas. Damage usually results when weeds, which are preferred host plants, are cleaned out of cotton. Total loss of foliage may result in small areas before the insects move out of the field. Spot treatment with the chlorinated hydrocarbons is usually effective for control of these outbreaks.

Whiteflies, Trialeurodes abutilonea (Hald.), T. vaporariorum Westw., and Bemisia tabaci (Germ.) are usually kept in check by parasites and diseases, but occasionally may be serious late in the season. Bemisia tabaci (Germ.) is reported to be a vector of the leaf crumple virus of cotton.

A white grub, Phyllophaga ephilida (Say), was reported to have destroyed 5 acres of cotton in Union County, North Carolina, during 1956. As many as 20 larvae per square foot were found. P. zavalana Reinhard is also reported to be a pest of cotton in the Matamoros area of Mexico, where the adults feed on foliage, particularly in the seedling stage. It is known to occur in Zavala and Dimmit Counties, Texas. P. cribosa Leconte, sometimes known as the "4 o'clock bug" in west Texas, has also been reported as feeding on young cotton in that area.

The white-lined sphinx (Celerio lineata (F.)) occasionally occurs in large numbers in uncultivated areas and migrates to cotton. It may be controlled on cotton with DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds per acre in a dust or spray. Migrations may be stopped with barrier strips of 10-percent DDT or 20-percent toxaphene or physical barriers.

INSECTS IN OR AMONG COTTONSEED IN STORAGE

Cottonseed rarely becomes infested while in storage when proper precautions are followed. Cottonseed or seed cotton should be stored only in a bin or room thoroughly cleaned of all old cottonseed, grain, hay, or other similar products in which insects that attack stored products are likely to develop. Among the insects that cause damage to stored cottonseed or to cottonseed meal are the cigarette beetle (Lasioderma serricorne (F.)), the Mediterranean flour moth (Anagasta kuhniella Zell.), the almond moth (Ephestia cautella (Wlk.)), and the Indian-meal moth (Plodia interpunctella (Hbn.)). Cottonseed that is to be used for planting only may be dusted with toxaphene before being placed in storage. Seed so treated should not be crushed or used for feed. The pink bollworm (Pectinophora gossypiella (Saund.)) may be found in stored cottonseed but such infestations would be present in the seed before they are stored (See page 46).

INSECT IDENTIFICATION

Prompt and accurate identification of insects and mites is a necessary service to research and to control of cotton insects. Applied entomologists owe much to taxonomists for their services, often rendered on a volunteer basis.

Approved common names are convenient and useful. Local or non-standard common names create confusion. Entomologists are urged to submit common names for approval, where such are needed.

Research in taxonomy has been productive of new developments. Major changes have been made in classification of spider mites attacking cotton. Several species of thrips and plant bugs have recently been added to the list of cotton pests. The Melanoplus mexicanus group of grasshoppers has been completely revised. Heliothis virescens has been accurately defined. Several scientific names have been changed.

COTTON-INSECT SURVEYS

The importance of surveys to an over-all cotton-insect control program has been clearly demonstrated. Surveys conducted on a cooperative basis by State and Federal agencies in most of the major cotton-growing States have developed into a broad, up-to-date advisory service for the guidance of county agents, ginners, farmers, and other leaders of agriculture who are interested in the distribution and severity of cotton insect pests, as well as industry which serves the farmers by supplying insecticides. As a result of this survey work, farmers are forewarned of the insect situation, insecticide applications are better timed, and losses are materially reduced

below what they would be without the information thus gained. The surveys also help to direct insecticides to areas where supplies are critically needed.

It is recommended that cotton-insect surveys be continued on a permanent basis, that they be expanded to include all cotton-producing States, and that the survey methods be standardized.

It is further recommended that the greatest possible use be made of fall, winter, and early-spring surveys as an index to the potential infestation of next season's crop.

Each year more people are being employed by business firms, farm operators, and others to determine cotton-insect populations. State and Federal entomologists should assist in locating and training personnel that have at least some basic knowledge of entomology.

Wherever possible, voluntary cooperators should be enlisted and trained to make field observations and records and to submit reports during the active season.

Surveys to detect major insect pests in areas where they have not previously been reported may provide information that can be used in restricting their spread or in planning effective control programs. The survey methods may include (1) visual inspection, (2) use of traps containing aromatic lures, (3) use of light traps, (4) use of mechanical devices such as gin-trash machines, and (5) examination of glass windows installed in lint cleaners used in ginning. The methods of making uniform surveys for several of the important insects are described below.

Light traps have provided valuable survey information for the following cotton insects: Beet armyworm, bollworms, brown cotton leafworm, cabbage looper, cotton leafworm, cutworms, fall armyworm, garden webworm, pink bollworm, salt-marsh caterpillar, white-lined sphinx, yellow-striped armyworm, and yellow woollybear.

Boll Weevil

Surveys to determine winter survival of the boll weevil are made in a number of States. Counts are made in the fall soon after the weevils have entered hibernation and again in the spring before they emerge from winter quarters. A standard sample is 2 square yards of surface woods trash taken from the edge of a field where cotton was grown the previous season. Three samples are taken from each of 30 locations in an area, usually consisting of three or four counties.

In the main boll weevil area counts are made on seedling cotton to determine the number of weevils entering cotton fields from hibernation quarters. The number per acre is figured by examining the plants on 50 feet of row in each of five representative locations in the field and multiplying the total by fifty. Additional counts are desirable in large fields. Square examinations are made weekly after the plants are squaring freely or have produced as many as three squares per plant. While walking diagonally across the field pick 100 squares, one-third grown or larger, and an equal number from the top, middle, and lower branches. Do not pick squares from the ground or flared or dried-up squares that are hanging on the plant. The number of squares found to be punctured is the percentage of infestation.

An alternative method is to inspect about 25 squares in each of several locations distributed over the field, to obtain a total of 100 to 500 squares, the number depending upon the size of the field and the surrounding environment. The percentage of infestation is determined by counting the punctured squares.

In both methods all squares that have egg or feeding punctures should be counted as punctured squares.

Bollworms

Examinations for bollworm eggs and larvae should be started as soon as the cotton begins to square and repeated every 5 days if possible until the crop has matured. While walking diagonally across the field, examine the top 3 or 4 inches of the main stem terminals, including the small squares, of 100 plants. Whole-plant examinations should be made to insure detection of activity not evident from terminal counts.

Cotton Aphid

To determine early-season aphid infestations, while walking diagonally across the field make observations on many plants, and record the degree of infestation as follows:

None, if none are observed.
Light, if aphids are found on an occasional plant.
Medium, if aphids are present on numerous plants and some of the leaves curl along the edges.
Heavy, if aphids are numerous on most of the plants and the leaves show considerable crinkling and curling.

To determine infestations on fruiting cotton, begin at the margin of the field and, while walking diagonally across it, examine 100 leaves successively from near the bottom, the middle, and the

top of the plants. Record the degree of infestation, as follows; according to the average number of aphids estimated per leaf:

None 0
Light ..... 1 to 10
Medium .....11 to 25
Heavy .....26 or more

Cotton Fleahopper

Weekly inspections should begin as soon as the cotton is old enough to produce squares. In some areas inspections should be continued until the crop is set. While walking diagonally across the field, examine 3 or 4 inches at the top of the main-stem terminals of 100 cotton plants, counting both adults and nymphs.

Cotton Leafworm

The following levels of leafworm infestation, on the basis of ragging and the number of larvae per plant, are suggested for determining damage:

None, if none are observed.
Light, if 1 or only a few larvae are observed.
Medium, if 2 to 3 leaves are partially destroyed by ragging, with 2 to 5 larvae per plant
Heavy, if ragging of leaves is extensive, with 6 or more larvae per plant, or if defoliation is complete.

Pink Bollworm

Counts to determine the degree of infestation in individual fields may be made early in the season by inspecting blooms, and later by inspecting bolls. Bloom inspections for comparing yearly early-season populations, or to determine when early insecticide applications are needed, should be made so as to obtain an estimate of the number of larvae per acre.

Bloom inspection: Five days after the first bloom appears, but not later than 15 days, check for number of larvae per acre as follows: Step off 300 feet of row (100 steps) and count the rosetted blooms at five representative locations in the field (1500 feet). Add the number of rosetted blooms from these five locations and multiply by 10 to obtain the number of larvae per acre.

Boll inspection: Check for the percentage of bolls infested as follows: Walk diagonally across the field and collect at random 100 firm bolls. Crack the bolls or cut each section of carpel (hull) lengthwise so that the locks can be removed; examine the inside of the carpel for mines made by the young larvae when entering the boll. Record the number of bolls infested on a percentage basis.

Other inspection techniques: There are other inspection methods that are helpful in directing control activities against the pink bollworm. They make possible the detection of infestations in previously uninfested areas and the evaluation of increases or decreases as they occur in infested areas. They are also used to determine the population of larvae in hibernation and their carryover to infest the new cotton crop.

1. Inspection of gin trash: Procure freshly ginned "first cleaner" trash, which has not been passed through a fan, from as many gins as possible in the area. Maintain the identity of each sample and separate mechanically all portions of the trash larger and all portions lighter in weight than the pink bollworm. A small residue is left which must be examined by hand. This method is very efficient for detecting the presence and abundance of the pink bollworm in any given area. One may locate the exact field by catching a separate trash sample from each grower's cotton.

2. Inspection of lint cleaner: During the ginning process the free larvae remaining in the lint are separated in the lint cleaners, and a substantial number of them are thrown and stuck on the glass inspection plates. All the larvae recovered are dead. For constant examination at a single gin, wipe off the plates and examine after each bale is ginned. In this way the individual field that is infested may be determined. For general survey, make periodic examinations to detect the presence of the pink bollworm in a general area.

3. Examination of debris: Between January and the time squares begin to form in the new crop, examine old bolls or parts of bolls from the soil surface in known infested fields. Examine the cotton debris from 50 feet of row at five representative points in the field for number of living pink bollworms. Multiply by 50 to determine number of living larvae per acre. Such records when maintained from year to year provide comparative data which may be used in determining appropriate control measures.

4. Use of light traps: Especially designed traps containing argon, mercury-vapor, or blacklight fluorescent bulbs will attract pink bollworm moths. Such traps are being used to discover new infestations, and their usefulness for survey work should be fully explored. Such traps are recognized as being an important means of survey for this pest as new infestations have been located through this use.

Spider Mites

Examine 25 or more leaves from representative areas within a field taken successively from near the bottom, the middle, and the top of the plants. Record the degree of infestation as follows, according to the average number of mites per leaf:

None	0
Light	1 to 10
Medium	11 to 25
Heavy	26 or more

Thrips

While walking diagonally across the field, observe or inspect the plants, and record the damage as follows:

None, if no thrips or damage is found.
Light, if newest unfolding leaves show only a slight brownish tinge along the edges with no silvering of the under side of these or older leaves, and only an occasional thrips is seen.
Medium, if newest leaves show considerable browning along the edges and some silvering on the under side of most leaves, and thrips are found readily.
Heavy, if silvering of leaves is readily noticeable, terminal buds show injury, general appearance of plant is ragged and deformed, and thrips are numerous.

Predators

Predator populations may be estimated by counting those seen while examining leaves, terminals, and squares for pest insects.

SCOUTING AND SUPERVISED CONTROL

Many farmers have used insecticides unnecessarily because of inadequate information on the presence of destructive insects and sometimes the treatments have been harmful to beneficial insects. When it is not possible for a farmer to supervise his own insect control program, two systems are used to assist him in controlling cotton pests.

Field scouting. Under this system, trained scouts inspect cotton fields at least at weekly intervals. They report the presence or abundance of injurious and beneficial insects to the farmer and usually to the county agent and the extension entomologist but they do not make control recommendations. Field scouting makes more accurate timing of insecticide applications possible and helps to eliminate useless treatments; furthermore it permits better use of natural and cultural controls in the program.

Supervised control. Under this system the grower employs a professional entomologist who not only scouts the fields for insects but makes specific recommendations to the grower for the control of the various pests based on infestation records in the particular field or block of cotton. It offers the same advantages as field scouting but the consultant also assumes the responsibility of making control recommendations.

EXTENSION EDUCATIONAL PROGRAM

The Situation

Reduction in yields of cotton due to insect damage costs farmers in this country approximately $250,000,000 per year. Insecticides and their application result in an additional cost in production of about $75,000,000. These figures are only estimates; however, there are lots of records available which show them to be highly conservative. Certainly this is too much of a toll to give in the production of any commodity. Theoretically, it is possible to eliminate the first item and it is likely that the per acre cost of controlling cotton pests can be lowered through research and education.

Many Share Responsibility

Cotton insect control recommendations to be published should be developed jointly by research and extension specialists. After the recommendations have been developed extension entomologists recognize the fact that it is their job to take the lead and guide the educational phase of the insect control program; however, the results desired, namely, better insect control, cannot be attained without the support of Federal and State research workers, farm magazines, newspapers, radio, TV, representatives of insecticide companies, and all others that have any part in disseminating information to growers on insect control.

More Extension Personnel and Scouts Needed

The States and the USDA spend yearly about $1,000,000 for research on the control of cotton pests not to mention the money spent by chemical companies that could rightly be charged to cotton insect control. This is not enough for research but even a much smaller amount is spent for technical leadership by extension. The greatest deficiency between the research plot and the farm is inadequate education. The extension entomologist is the person that has the responsibility of formulating and projecting the educational phase of a cotton insect control program. In most States there is definite need for additional extension personnel. Many more farmers or groups of farmers need to employ scouts to check fields. Scouts are usually college students that have been trained to check cotton fields to determine the presence and abundance of pests and beneficial insects.

Observations made throughout the Cotton Belt show that only the exceptional grower controls cotton insects as effectively as they are controlled in experimental areas. What then can be done to get the best known control procedures adopted on all farms?

Roadblocks That Need to be Removed

First of all, we must realize that cotton producers generally know very little about cotton pests and their life habits. Most of them know even less about the many pesticides that are recommended for use on cotton. Therefore, a prime requirement for getting better control is to teach growers more about insect identification, life histories, and controls. Uniformity of recommendations within a given State is most important. Many growers start their control program when their neighbors start without regard to the insect situation in their fields. This is due in a large degree to such phrases as "early control," "preventive control," "mid-season control," etc. All must agree that there are too many control programs. This adds to the confusion in the minds of growers. A control program must be made simple. Growers should do only those things that are necessary to prevent damage to the crop.

These situations must be recognized at the State level and plans made to attack the problem at meetings held at the State, county, and community levels. Attendance at such meetings should include farmers, ginners, insecticide dealers, bankers, cotton handlers, and all others with a direct interest in cotton production.

Setting the Stage for Action

Factors other than identifying the problems and control recommendations that should be discussed at meetings include: the importance of surveys; scouting of individual fields; when insecticides should and should not be used; importance of proper adjustment of equipment used in applying pesticides; rate of application; interval between applications and such things as nozzle size, nozzle placement, and the effect of air currents in the application of dust formulations.

Coordinated Attack

More meetings with farmers, leaders, ginners, insecticide representatives, bankers, and cotton handlers are a must if the profits from cotton production are to be increased materially. At such meetings all timely phases of cotton production should be discussed. Ample time should be given to a discussion of questions that are in the minds of growers. All kinds of visuals, charts, etc., should be used in order to make recommendations clear, brief, and as explicit as possible.

Personal visits by the specialists and county agents with insecticide and equipment dealers in a county can be an important

factor in getting better insect control on the farm. It is quite likely that the insecticide dealer more often than any other person decides which pesticide will be used on a large percent of the farms that grow cotton.

Plans should be made that will insure close cooperation between Federal and State survey entomologists and paid scouts. It is suggested that all scouts in a given county or State, regardless of their employer, be supervised by an extension specialist or the county agricultural agent. All scouts within a county should meet weekly with the county agent.

Demonstrations a Must

Demonstrations showing people how to do things are as old as the extension service. Method and result demonstrations are important tools to use in getting growers to adopt the best recommendations for the control of cotton insects.

After the growing season has started, nothing will take the place of good method demonstrations. Method demonstrations should include identification of insects, good ones as well as those that will cause damage, how to check infestations, how to calibrate a sprayer or adjust a duster to insure the applications of the needed amount of toxicant, placement of nozzles of outlets on dusters that will give good coverage and other factors that may be of importance in some areas and not in others.

A few result demonstrations strategically located over the State and closely supervised by extension personnel will go a long way toward getting better control practices adopted.

Persistent Use of Mass Educational Media Necessary

The importance of a good publicity program cannot be overemphasized. Feature articles in farm magazines during the fall or winter reporting on results of research and result demonstrations are good. Articles run in spring numbers should explain clearly recommendations for the current year. News articles for State and county papers are important but should be much shorter than those used in farm magazines. Articles for newspapers should be released throughout the growing season.

Radio and television are the ideal ways to release results of weekly survey reports and emergency suggestions on control programs.

Visuals of all kinds including live material should be used at every opportunity in meetings and with television programs. People still see better than they hear or listen.

NEEDED RESEARCH

Additional information is needed on many phases of cotton insect control to make it more effective and economical. It is generally agreed that if cotton is to retain its position in the world market, production costs must be reduced. One important means of doing so is through the development of less costly insect control programs. New approaches to control of the various pests must be developed to effect this need. A concentrated, cooperative, and coordinated effort of State, Federal, and Industry research entomologists as well as of scientists in related disciplines is needed to solve the problem. This effort should be directed toward the following lines of research:

1. Chemical Control. For the foreseeable future, the farmer must continue to rely on chemicals to meet his insect problems.

   (a) Conventional insecticides. Because of the insecticide resistance problem and the possible immediate need for substitute insecticides, the development of additional insecticides, particularly those having different modes of action, to control several cotton pests is of prime importance.

      (1) Chemical defoliation and plant desiccation should be studied in relation to the abundance of pests and to development of late-season broods. The value of these practices in a late-season control program and their use with other insecticides with a possibility of controlling or eradicating certain pests should be evaluated.

   (b) New approaches to chemical control. Additional research on chemicals for cotton insect control should be directed primarily to new approaches to this control with emphasis on the following:

      (1) Chemically induced plant resistance to insect attack.

      (2) Systemics for seed, soil, or foliage treatment.

      (3) Baits and other attractive substances.

      (4) Exploration of the possibilities of developing growth regulating chemicals.

      (5) Synthesis of insecticides tailored to control a particular pest.

(c) Toxicity and residues.

(1) Toxicity of all candidate insecticides to warm-blooded animals must be determined.

(2) Analyses must be made to establish the nature and extent of residues that appear in cottonseed products when new chemicals are under development for practical control.

2. Plant Morphology, Physiology, and Varietal Resistance in Cotton.

(a) The relationship of an insect's development to the morphological and physiological changes in the cotton plant.

(b) The development of varieties which are highly resistant to one or more of the important cotton pests would go a long way toward reducing the cost of cotton production by reducing cost of insect control.

3. Basic Investigations on Insect Taxonomy, Biology, and Ecology.

(a) Accurate identification of insect pests is essential to avoid confusion and permit immediate control of outbreaks. It is particularly important in species where large differences in susceptibility to pesticides are evident, as in cutworms and the spider mites. Taxonomic and biological studies of the cabbage looper and related species and the yellow woollybear are needed.

(b) The physiology of cotton pests should be studied with particular emphasis on the growth mechanisms and on ways of upsetting such mechanisms.

(c) Determine how the various pests develop resistance to a pesticide and devise means by which this may be prevented or reversed.

(d) Ecological studies are needed on all important cotton pests for the development of more effective or new approaches to control.

4. Biological control. The development of biological agents for the control of cotton pests should be explored.

(a) Pathogens. Any disease organisms, bacteria, protozoa, nematode, virus, or fungi found to be pathogenic to insects should be investigated.

(b) Parasites and predators. Possibilities of production and mass releases of effective parasites and predators for the control of particular pests should be investigated.

(c) Genetic control. The possible use of sexually sterile males and other genetic methods for the control or eradication of certain pests should be evaluated.

5. Develop Information on Effects of Insects on Cotton Quality

The quality of cotton produced reflects its value at the market place. The effect of insect attack on the quality of lint and seed and the effect of control measures on the quality of the crop must be evaluated.

6. Improved Insect Surveys. Improved survey methods and assembly of information are needed to permit the forecasting of insect outbreaks and damage.

7. Develop More Efficient Equipment for Applying Insecticides. Improvements are badly needed in both ground and aerial equipment used in applying insecticides. Techniques for improving distribution might improve control to the extent that more efficient control with less insecticide might be attained.

CONFEREES AT THIRTEENTH ANNUAL CONFERENCE

One hundred and six entomologists and associated technical workers concerned with cotton-insect research and control participated in this conference. They were from the agricultural experiment stations, extension services, and other agencies in 12 cotton-growing States, the United States Department of Agriculture, and the National Cotton Council of America. The statements in this report were agreed upon and adopted by the following conferees:

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